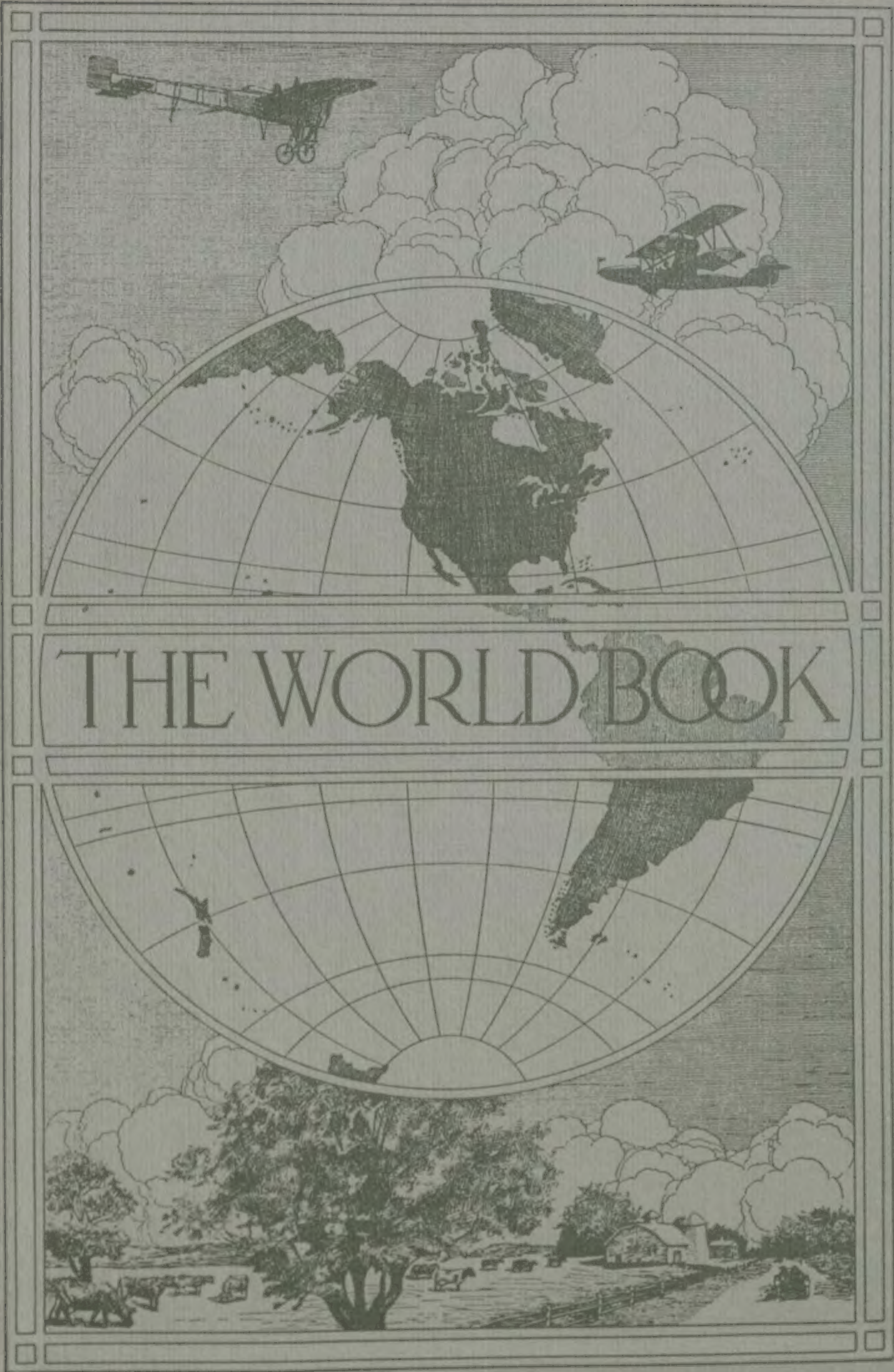
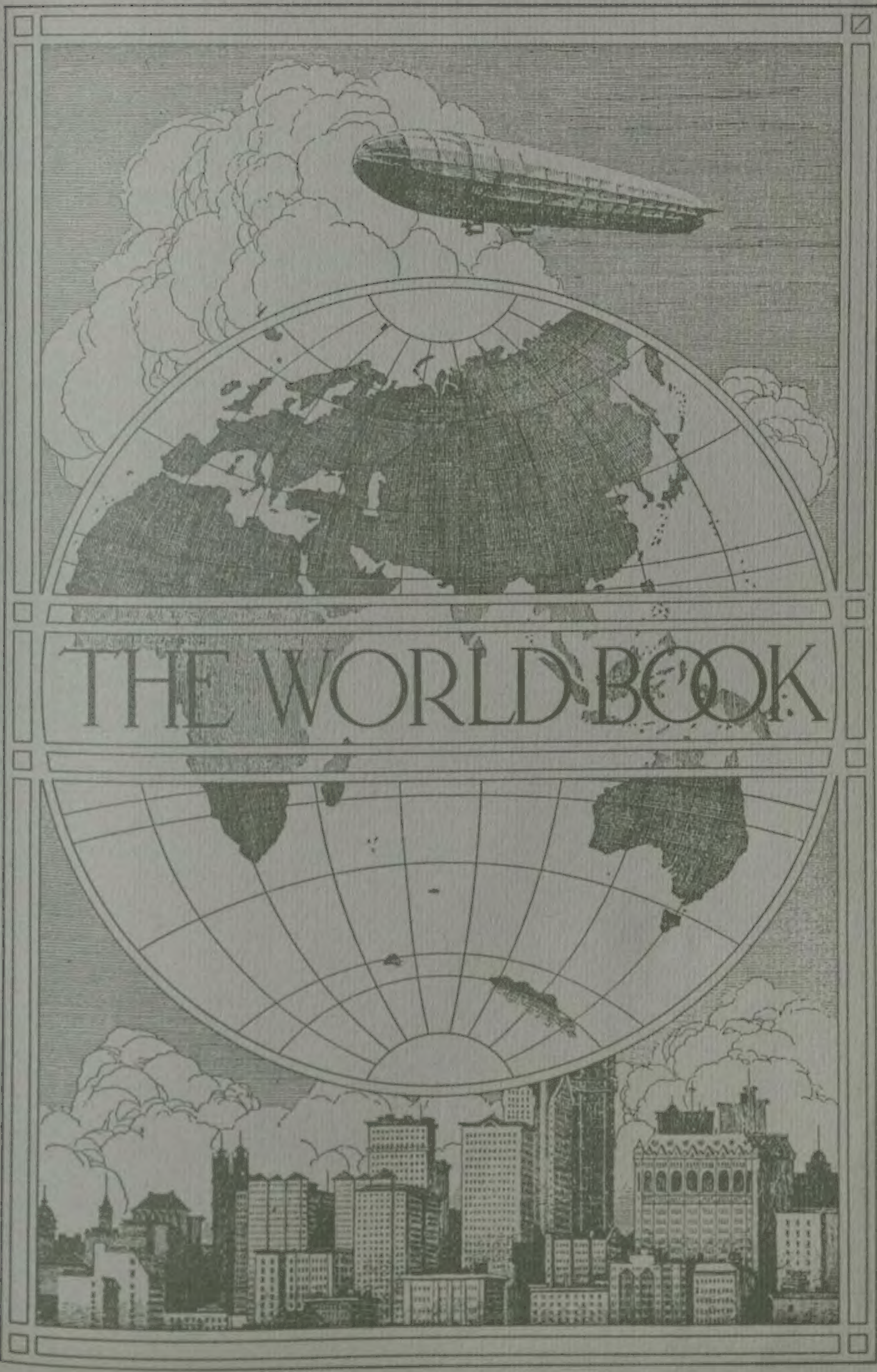
THE WORLD BOOK


THE WORLD BOOK


THE WORLD BOOK

F Volume 7

49/7

The World Book Encyclopedia

World Book International

World Book Inc.

A Scott Fetzer company

London Sydney Tunbridge Wells Chicago

The World Book Encyclopedia
(International)

"World Book" Reg. U.S. Pat. & T.M. Off. Marca Registrada

ISBN 0-7166-6696-0

Library of Congress Catalog Card Number 95-61137

Printed in the United States of America

1 2 3 4 5 99 98 97 96

Ff

F is the sixth letter of the English alphabet. Historians believe that the letter came from a symbol used by the Semites, who once lived in Syria and Palestine. They named it *waw,* meaning *hook.* The ancient Greeks later took the symbol into their own alphabet and called it *digamma.* They used it to represent the sound of *w* in English. The Romans were the first to use the letter to represent our sound for *f.* See **Alphabet.**

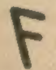
Uses. *F* or *f* is about the 15th most frequently used letter in English. When used on a report card, *F* usually means failure in a school subject. In music, it names one note of the scale. As an abbreviation, *F* shows that a temperature reading is in Fahrenheit degrees. *F* means *fluorine* in chemistry, *function* in mathematics, *fluid* in pharmacy, *free energy* in physics, and *frequency* in statistics. In photography, *f* refers to the focal length of the lens divided by its actual opening. The letter *f* also stands for *franc* (in France and certain other countries).

Pronunciation. In English, a person pronounces the letter *f* by placing the lower lip against the edges of the upper front teeth and forcing the breath out. A person pronounces *ff* as a single *f,* except when the letters appear in combinations of two words, such as *self-fed.* In some English nouns, such as *knife,* the *f* becomes a *v* in the plural form of the word. The *f* in French, Italian, Spanish and German words resembles the English *f* sound. The Latin pronunciation of *f* is also similar to the English *f* sound. In Old English, *f* between vowels was pronounced as a *v.* In the Welsh language, *f* always sounds like *v.* See **Pronunciation.**

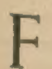
Development of the letter F

The ancient Egyptians drew this symbol of a hook about 3000 B.C. The Semites adapted the symbol and named it *waw,* their word for *hook.*

The Phoenicians used this symbol of a hook in their alphabet about 1000 B.C.

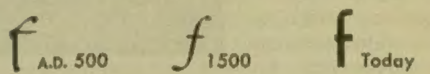


The Greeks, about 800 B.C., changed the symbol and made it the sixth letter of their alphabet. They called it *digamma.*



The Romans gave the capital F its present form about A.D. 114.

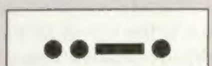
The small letter f developed about A.D. 500 from Roman writing. Monks who copied manuscripts modified the letter during the 800's. By about 1500, the f had its present shape.



Special ways of expressing the letter F

F

International Flag Code



International Morse Code

Braille

American Sign Language

British Sign Language

Semaphore Code

Common forms of the letter F

F f *Ff*

Handwritten letters vary from person to person. *Manuscript* (printed) letters, *left,* have simple curves and straight lines. Cursive letters, *right,* have flowing lines.

Ff *Ff*

Roman letters have small finishing strokes called *serifs* that extend from the main strokes. The type face shown above is Baskerville. The italic form appears on the right.

Ff *Ff*

Sans-serif letters are also called *gothic letters.* They have no serifs. The type face shown above is called Futura. The italic form of Futura appears on the right.

F

Computer letters have special shapes. Computers can "read" these letters either optically or by means of the magnetic ink with which the letters may be printed.

Faber, Eberhard (1822-1879), a Bavarian-born American businessman, built the first mass-production pencil factory in the United States. His great-grandfather had started making pencils in Bavaria in 1761. Faber moved to New York City in 1848 and opened a branch of the family firm there the next year. He sold pencils shipped from Bavaria and also exported cedar boards from Florida to European pencil manufacturers.

Faber had to pay a tariff on the pencils he imported, and so he decided it would be cheaper to make them himself. He developed labour-saving machinery to avoid high production costs and, in 1861, built a pencil factory in New York City. Faber later expanded the business to include pens, erasers, and other stationery products. Faber was born in Stein, near Nuremberg, in Bavaria, Germany.

Fabergé, Peter Carl (1846-1920), was a Russian goldsmith and jeweller who won international fame for his design of decorative objects. His imaginative creations included cigarette cases, picture frames, parasol handles, and miniature flowers and animals, as well as clocks and other traditional items.

Fabergé's objects were made from gold, silver, and various gemstones native to Russia. He decorated many items with a brilliantly coloured enamel that was characteristic of his work. Fabergé's most famous pieces are the beautifully crafted Easter eggs he made for Czars Alexander III and Nicholas II.

The Resurrection Egg (about 1889), by Peter Carl Fabergé. Gold, diamonds, and pearls, with enamelled figures.

A Fabergé egg

Fabergé was born in St. Petersburg. He received his first training from his father, who was a successful jeweller, and inherited the small family business at the age of 24. He expanded the business into a company with workshops in the cities of Kiev, Moscow, Odessa, and St. Petersburg, and eventually in London. Czar Alexander III appointed him imperial jeweller in 1884. The Soviet government took over Fabergé's firm after the Bolshevik Revolution of 1917. Fabergé fled to Switzerland, where he died.

Fabianism, a socialist movement, began in 1884 with the formation of the Fabian Society in London. It had the object of "reconstructing society in accordance with the highest moral precepts." It was named after the Roman general Quintus Fabius Maximus, whose nickname was *Cunctator* (Delayer). The Fabians modelled their tactics on his caution, believing in socialism through evolution and not by revolution.

Early Fabians included George Bernard Shaw and Sidney Webb. Later members included Beatrice Webb, H. G. Wells, G. D. H. Cole, and J. A. Hobson. The Fabians based their political and economic theories, which included the nationalization of land and capital, more on the works of John Stuart Mill than on those of Karl Marx.

The Fabians helped lay the foundations for the formation of the British Labour Party in the early 1900's. The

Engraving (1879) by William Salter Herrick

The fable "The Fox and the Grapes" tells of a fox who wants to eat a bunch of grapes on a vine. After he finds he can't reach the grapes, he decides that they were probably sour anyway.

Fabians advocated Poor Law reforms. In 1912, Beatrice and Sydney Webb founded the Fabian Research Department, which conducted inquiries into social, trade union, and cooperative questions. In 1915, this body became the Labour Party Research Department, and the Fabians, as such, ceased to function.

Labour leaders founded the Fabian Research Bureau in the early 1930's. It published literature on social and political matters. A new Fabian Society, formed in 1938, grew rapidly in Britain and other Commonwealth countries. Many trade union leaders, trade unionists, and Labour members of Parliament joined the society.

See also **Cole, G. D. H.; Hobson, John Atkinson; Shaw, George Bernard; Wells, H. G.**

Fable is a brief fictitious story that teaches a moral. In most fables, one or more of the main characters is an animal, plant, or thing that talks and acts like a human being. A fable may be told in prose or in verse. In many fables, the moral is summed up at the end in the form of a proverb.

Famous fables include "The Fox and the Grapes," and "The Wolf in Sheep's Clothing." These tales have been told and retold for more than 2,000 years. They remain popular because they illustrate truths that almost anyone can recognize. In "The Fox and the Grapes," for example, a fox decides that some grapes that are growing too high for him to reach are probably sour anyway. A person who hears the tale will recognize the fox's attitude as a common human failing. The moral of the fable—that people often express a dislike for something they cannot have—is summed up in the expression "sour grapes."

Nearly all ancient peoples invented folk tales in which animals have human traits. The fox was often pictured as sly, and the owl as wise. In time, people began to tell the stories to teach morals. The tales thus became fables.

Most of the fables that are popular in Western countries can be traced back to ancient Greece and India. The majority of the Greek fables are credited to Aesop, a Greek slave who lived about 600 B.C. Aesop had a reputation for telling wise, witty tales about animals, but scholars know little else about him. The fables known as "Aesop's fables" probably came from several ancient sources. Some of the stories originated in India.

The fables of the people of India were influenced by their belief that after death, human beings might be reborn as animals. Indian storytellers made up many tales of such rebirths and used them to teach a variety of morals. Some of these fables had reached the West by the start of the Christian era and were included in early collections of Aesop's fables. During the 200's B.C. or after, the Indians collected their best-known fables in a work called the *Panchatantra.*

Through the centuries, many writers have retold the ancient fables. The most famous such writer was Jean de La Fontaine, a French poet of the 1600's. La Fontaine retold Aesop's fables in elegant verse and expanded their meanings. Fables had always made fun of human follies, but La Fontaine turned such satire into biting social criticism. In "The Fox and the Crow," for example, a fox robs a crow of some cheese by telling him what a fine singing voice he must have. As the flattered crow opens his mouth to caw, the cheese drops from his beak. Earlier versions of the fable poked fun at the crow for being fooled by the fox's flattery. La Fontaine's version includes the trickery of the fox and ends with a thoughtful moral: "Every flatterer lives at the expense of his listeners." La Fontaine wrote his fables mainly for adults, but they have long been favourites of French children.

La Fontaine has had many imitators. One of the most successful was Ivan Krylov, a Russian poet of the early 1800's. Krylov translated La Fontaine's fables into Russian and also wrote many of his own. He intended his stories mainly for adults. But they have become the most popular children's stories in Russia.

During the 1900's, writers have continued to develop the fable as a literary form.

See also **Aesop's fables; Allegory; Folklore; La Fontaine, Jean de; Literature for children** (Folk literature).

Fabre, Jean Henri Casimir (1823-1915), a French naturalist, spent his life observing insects and spiders. He wrote simply of what he saw in the gardens and fields near his home. He received the ribbon of The Legion of Honour, but was fired from his teaching position because he allowed girls to attend his science classes. Fabre was almost unknown outside France until he was nearly 80. Then the great scientific societies recognized his accomplishments. He wrote a 10-volume *Souvenirs Entomologiques.* Fabre was born in St. Léon, in central France. He spent much of his adult life in the village of Sérignan, in the southern province of Vaucluse. His house and garden there are now a museum.

Fabric. See **Textile.**

Face is the front part of a person's head. It consists of the forehead, eyes, nose, mouth, cheeks, and chin. The face is covered with muscles and skin. The eyes are protected from glare and dust by the eyelids, lashes, and eyebrows. The tip of the nose is made up of cartilage and skin, which act as a flexible cushion. The channels of the nose are covered with tiny hairs which strain out dust and dirt in the air going through the nose. The mouth includes the lips, teeth, tongue, and roof, and is lined with mucous membrane. The lower jaw is the only bony part of the face that moves.

The facial skeleton is made up of 14 bones and 32 teeth. The *frontal bone* forms part of the forehead. The *nasal bones* and *lacrimal bones* combine to support the bridge and base of the nose. The middle portion of the face, including the cheekbones and upper jawbones, is formed by the *zygomatic bones* and *maxillae.* The *mandible* forms the jaw. The *vomer bones, ethmoid bones,* and *palatine bones* lie deeper in the face. There are also a number of muscles in the face. There is a circular muscle around the mouth and one around each eye. Other muscles spread out over the face from the edges of the circular muscles.

The face is the most distinctive part of a human being. It differs in each person because of variations in the nose, eyes, and other parts of the face. It is because of these variations that we recognize each other and tell one another apart. Much of what goes on in our mind finds expression in our face. We cannot always control our expression.

See also **Bell's palsy; Blushing; Head; Mandible.**

Facet. See **Diamond** (How diamonds are cut to make jewels; pictures).

Facey, Albert (1894-1982), an Australian, became a best-selling, prizewinning author when his autobiography, *A Fortunate Life,* was published in 1981. His simply told but eventful story coincides with much legendary Australian experience. Deserted by his widowed mother, Facey and the other children were brought up in poverty by their grandmother in rural Western Australia. He began work at the age of 8, and was exploited and beaten as if he were a slave. He worked on cattle stations and became a drover. As a teen-ager, he worked on the railways before joining a travelling boxing troupe. He fought at Gallipoli, during World War I, and on his return to Australia, married and became a soldier settler. During the Great Depression of the 1930's, he moved to Perth and became an organizer in the Tramways Union.

Albert Barnett Facey was born in Maidstone, Victoria, Australia. He had no formal education and taught himself to read and write when he was an adult.

Facsimile, often called *fax,* is a way of transmitting text and pictures over telephone lines. News services often use facsimile to send news stories and photographs to newspapers and television stations. Banks, law firms, and other businesses use facsimile to send copies of documents to clients and other organizations.

A device called a *facsimile machine* is used for transmitting and receiving images. Facsimile machines resemble small photocopiers. However, they are equipped with a telephone or are connected to one. To send a document, the user inserts it into the machine and dials the telephone number of the receiving fax machine. After the connection is made, an electronic scanner on the transmitting machine moves across the page and converts the image into a set of electric signals. These signals travel over the telephone line to the receiving fax machine. That machine converts the electric signals back into an image of the original document and then prints a copy.

A facsimile machine transmits images over telephone lines. This woman is receiving an image sent on another machine.

Some business people use small desktop fax machines or portable models at home or when they travel. A personal computer can also be used to send and receive documents if it is equipped with a special electronic circuit board called a *fax board.*

Many inventors in Europe and the United States worked on facsimile in the late 1800's and early 1900's. News services began using fax machines to transmit photographs in the 1930's. At that time, fax machines used radio waves instead of telephone lines for transmission. Facsimile became increasingly popular in business in the 1980's after manufacturers developed machines that were smaller, less costly, and faster.

See also **Telephoto.**

Factor. The factors of a number are the numbers that when multiplied together give the original number. The numbers 3 and 4 are factors of 12 because $3 \times 4 = 12$. The other whole number factors of 12 are 2 and 6, and 1 and 12. *Factoring* (determining factors) provides insight into one of the many relationships among numbers.

Every whole number, except 1, can be expressed as the product of at least two factors. A number that has only two different factors, itself and 1, is called a *prime number.* The number 7 is prime because 1 and 7 are its only factors. The eight smallest primes are 2, 3, 5, 7, 11, 13, 17, and 19. A number that has more than two factors is called a *composite number.* The number 4 is composite because it has three factors, 1, 2, and 4. The eight smallest composite numbers are 4, 6, 8, 9, 10, 12, 14, and 15. The number 1 is neither composite nor prime.

Prime factors of a number are those prime numbers that when multiplied together equal the number. Each number is a product of only one set of prime numbers. For example, 24 can only be expressed as a product of prime numbers as $2 \times 2 \times 2 \times 3$ (in any order). The *prime factorization* of 24 is $2 \times 2 \times 2 \times 3$ and the *prime factors* of 24 are 2 and 3.

To find the prime factors of a number, divide the number by any *prime number* that goes into it evenly. It is usually easiest to use the smallest prime number that divides the number evenly. For example, to find the prime factors of 220, begin by dividing by 2 ($220 \div 2 = 110$). Continue dividing the *quotient* (the number obtained) by 2 until it is no longer divisible by 2 ($110 \div 2 = 55$). But 55 cannot be divided by 2 without leaving a remainder. The next prime, 3, does not divide into 55 without a remainder either. But the next greater prime, 5, does divide into 55 equally ($55 \div 5 = 11$). The number 11, like 2 and 5, is a prime number. Therefore the prime factorization of 220 is $2 \times 2 \times 5 \times 11$ and the prime factors are 2, 5, and 11. The product $2 \times 2 \times 5 \times 11$ (in any order) is the only way 220 can be expressed as the product of prime numbers. The process may be written thus:

$$\begin{array}{r|l} 2 & 220 \\ 2 & 110 \\ 2 & 55 \quad \text{(leaves a remainder)} \\ 3 & 55 \quad \text{(leaves a remainder)} \\ 5 & 55 \\ & 11 \quad \text{(prime)} \end{array}$$

The only factors of a prime number are the number itself and 1.

Common factors. If a number is a factor of two or more numbers, it is called a *common factor* of those numbers. For example, 1, 3, 5, and 15 are the factors of 15; and 1, 2, 4, 5, 10, and 20 are the factors of 20. One and 5 are common to both these sets of factors.

If two numbers have more than one common factor, the greatest one is called the *greatest common factor.* It is also the *greatest common divisor* since a factor of a number is also a divisor of that number. For example, the numbers 30 and 45 have four common factors: 1, 3, 5, and 15. The greatest common factor is 15. To find the greatest common factor of two or more numbers, first find the set of all the factors for each number. Then select the largest factor which is in all the sets. The greatest common factor of 18, 30, and 42 is in this example:

Number	Set of factors
18	1, 2, 3, 6, 9, 18
30	1, 2, 3, 5, 6, 10, 15, 30
42	1, 2, 3, 6, 7, 14, 21, 42

The number 6 is the greatest factor common to all the sets, so 6 is the greatest common factor of 18, 30, and 42.

Relative primes. Two numbers that have no common factors other than 1 are *relatively prime* or *prime in relation to each other.* For example, the factors of 12 are 1, 2, 3, 4, 6, and 12. The factors of 35 are 1, 5, 7, and 35. Twelve and 35 have no common factors other than 1. They are relatively prime.

Algebraic factors. *Algebraic expressions* ($2x + 4$ is an algebraic expression) also have factors. For example, $1, 3, a, b,$ and ab are factors of $3ab$. The expressions $1, a, a^2, b$ and a^2b are factors of a^2b. The factors of algebraic expressions are found in the same way as the factors of whole numbers. Multiplying $2ab$ by $(a + 2b)$ gives $2a^2b + 4ab^2$. Therefore, $2ab$ and $a + 2b$ are factors of $2a^2b + 4ab^2$. The other factors of $2a^2b + 4ab^2$ are $1, 2, a, b,$ and ab. The expression $a^2 + b^2$ cannot be factored using real numbers only. Its factors are *complex numbers.* A com-

plex number is the sum of a real number and an *imaginary number* (the square root of a negative number).

See also **Algebra** (Factoring); **Numeration systems** (The decimal system).

Factory is a building or group of buildings in which products are manufactured. Factories range in size from home garages to buildings covering whole city blocks. Inside, workers and machines turn raw materials and parts into finished products. Factories make almost all the products people use except food. But numerous factories treat, prepare, or package food products.

Kinds of factories. Factories use the principle of *division of labour*—that is, they divide the required work into a number of separate operations. There are three main kinds of factories: (1) repetitive factories, (2) job factories, and (3) job-lot factories.

Repetitive factories make many units of the same product. Car makers use a repetitive approach called the *assembly-line* method, in which the car frame moves on a conveyor through the factory. As the frame moves, parts arrive on other conveyors and get attached to the frame until the car is completed. See **Car** (illustration: Assembling a car).

Job factories, also called *project factories,* make only a small number of units of the same product. They include aircraft factories. In aircraft plants, the product cannot be moved from station to station because of its great size. Instead, workers and equipment must be moved to the product. Completing one item may take months.

Job-lot factories combine repetitive factory and job factory methods. Machines are set up to make a certain number of units of a product. Once that number is finished, the machines make another kind of product.

Location and design. Most manufacturers build their factories in suburban areas, where land costs less than in the centre of cities. Many new plants have a one-storey structure, which permits materials to move easily through them.

An aeroplane factory brings together skilled workers and sophisticated equipment to build a modern jet plane, *above.*

To make factories more efficient, some manufacturers use computers to link the operations of various machines and to control the flow of work through the plant. These computers enable a few technicians to survey and operate the entire factory. Such factories may use robots and computer-controlled machine tools. These devices often provide safer, more efficient ways to perform tiring or dangerous tasks. Such tasks include welding, spray painting, and transporting heavy machinery.

History. Before the development of factories, workers made most manufactured products in homes or shops. The development of power-driven machines in the 1700's and 1800's made the modern factory system possible (see **Industrial Revolution**). Until the 1900's, factories were often dirty and dimly lit, and many were dangerous places in which to work. Most of them stood crowded together in industrial sections of large cities. Today, most factories have good lighting and air conditioning. Many provide music, cafeterias, and medical staff for their employees.

Related articles in ***World Book*** include:

Automation	Labour force
Electricity (In industry)	Manufacturing
Industrial relations	Mass production
Industrial Revolution	Sweatshop
Industry	Technology
Invention	

Factory acts protect people who work in British factories. The Factories Act of 1961, which replaced previous factory acts, covers all conditions of work in factories. It forbids overcrowding, lays down standards of cleanliness, and provides for adequate ventilation and light, and a working temperature of 16° C. It also requires employers to take safety precautions and to provide medical facilities. It limits the number of hours of work, and requires that employees should have several rest and meal periods every day.

The Health and Safety at Work Act of 1974 was passed to reorganize the system of safeguards for health and safety. The Act set up a Health and Safety Commission to develop and carry out policies to provide health and safety. Members of the commission represent employers, trade unions, or local government authorities. The commission supervises the Health and Safety Executive, which organizes inspection of places of work to check safety standards. Inspectors can order employers to improve standards of protection for their workers and can give expert advice on ways of improving safety. They encourage businesses to appoint their own safety officers and safety committees.

When the Industrial Revolution began in the 1700's, there were no laws to regulate the conditions under which people worked in factories (see **Industrial Revolution**). Employers forced men, women, and children to work for long hours under horrifying conditions. One of the first protective Acts was the Health and Morals of Apprentices Act of 1802, which improved the working conditions of young apprentices. In 1833, Parliament passed the first effective Factory Act. Under this Act, the government appointed inspectors to make sure that conditions in factories met required standards. In 1871, Parliament passed the Workmen's Compensation Act, to provide workers with financial compensation for injuries caused by accidents at work.

Fadden, Sir Arthur (1895-1973), an Australian politician, was prime minister of Australia from August to October 1941. He was leader of the Country Party until 1958. When R. G. Menzies resigned as prime minister in 1941, Fadden succeeded him. He was defeated soon afterward. He then led the opposition until 1943. Meanwhile, Menzies founded the Liberal Party. In the elections of 1949, the Liberal and Country parties formed a coalition, and Fadden became federal treasurer. He retired in 1958. Arthur William Fadden was born in Ingham, Queensland, Australia. He entered Parliament in 1936, and was knighted in 1951.

Faeroe Islands. See **Faroe Islands**.

Fafnir, in Scandinavian mythology, was a man who turned himself into a dragon. Poems and stories from medieval Iceland describe Fafnir as a powerful, greedy, and violent man with magical powers. Fafnir killed his father, Hreidmar, and stole his family's gold. He then turned himself into a dragon and spent the rest of his life guarding the gold. Fafnir's brother Regin tried to get the gold back and asked the hero Sigurd to kill Fafnir. Regin planned to betray and kill Sigurd after Fafnir's death.

Fafnir left his lair occasionally to drink water from a nearby river. Sigurd dug a hole in the path that led to the river. He hid in the hole until Fafnir crawled over it. Sigurd then used his sword to stab Fafnir in the heart. Sigurd roasted the dragon's heart, and by tasting its magic juice, he was able to understand the language of birds. The birds warned Sigurd that Regin was planning to kill him, so Sigurd killed Regin.

German composer Richard Wagner told a version of this story in his opera *Siegfried.* In the opera, Fafnir is slain by the Germanic hero Siegfried.

Fahd (1923-) became king and prime minister of Saudi Arabia in 1982, following the death of his half-brother King Khalid. When Khalid became king in 1975, he named Fahd crown prince and first deputy prime minister of Saudi Arabia. Fahd ran the day-to-day affairs of the government because Khalid was not in good health and he lacked Fahd's detailed experience of government functions. Fahd has tried to maintain Saudi Arabia's traditional Islamic moral values while continuing the process of rapid modernization made possible by the country's great oil wealth.

In August 1990, Iraqi forces invaded and occupied oil-rich Kuwait. Many people feared Iraq would next invade Saudi Arabia. Fahd invited foreign troops, including those from the United States, to come to Saudi Arabia to defend that country. The Saudis and foreign nations formed an alliance. In February 1991, under U.S. military leadership, these allies drove the Iraqis out of Kuwait. See **Persian Gulf War**.

In 1993, Fahd appointed a 60-member consultative council to advise him on government matters. The council had no legislative powers, but it provided Saudi citizens with a voice in the government.

Fahd was born in Riyadh, Saudi Arabia. His full name is Fahd ibn Abd al-Aziz al-Saud. From 1953 to 1960, Fahd served as Saudi Arabia's first minister of education. In 1962, he was appointed minister of the interior. In 1967, he also became second deputy prime minister.

Fahrenheit, Gabriel Daniel (1686-1736), a German physicist, developed the Fahrenheit temperature scale. He also made the thermometer more accurate by using mercury instead of mixtures of alcohol and water in the thermometer tube (see **Thermometer**).

Fahrenheit determined three fixed temperatures: 0 °F for the freezing point of ice, salt, and water; 32 °F for the freezing point of pure water; and 212 °F for the boiling point of water. These three temperatures, from lowest to highest, are equal to −18°, 0°, and 100° on the Celsius temperature scale. Later experiments proved the normal body temperature to be 98.6 °F, or 37 °C. Fahrenheit was born in Danzig (now Gdańsk, Poland).

Faïence is a kind of earthenware. Faïence is glazed with tin oxide to produce a creamy white colour. The ware can be decorated with other metallic oxides that turn various colours when the pottery is *fired* (baked). Faïence is related to two other types of earthenware,

A faïence dish and plate show the elaborate decoration that made this kind of French pottery famous. The bird-shaped dish was made during the 1700's. The plate, which has a delicate snowflake design, also dates from that period.

majolica and delft. But the three have different forms of decoration and also assumed their characteristic style in different countries. Faïence came from France, majolica from Italy, and delft from the Netherlands.

The French named faïence after Faenza, Italy, the centre for the production of tin oxide-glazed pottery during the 1500's. Today, Germany, Scandinavia, and Spain produce tin oxide-glazed wares known as faïence.

Fainting is a temporary loss of consciousness. The fainting person becomes pale, begins to perspire, and then loses consciousness and collapses. The person also has a weak pulse and breathes irregularly. Fainting usually lasts only a few minutes. As the fainting passes, the muscles become firm, the pulse is stronger, and breathing becomes regular.

A fainting spell can be relieved by having the victim lie on the floor with the legs slightly elevated.

Fainting occurs when there is an insufficient supply of blood to the brain for a short period of time. This condition results from a *dilation* (widening) of the blood vessels in the body followed by a drop in heart rate and blood pressure. It is usually triggered by emotional shock or by physical factors such as the accumulation of blood in the legs as a result of standing still for a long period of time.

Fainting should be treated by letting the person lie stretched out with the head slightly lower than the body. The person's clothing should be loosened, and the individual should be given plenty of room and air. In some cases, a person can be revived by bathing the face with cool water or by passing a whiff of smelling salts under the nostrils. See First aid (Fainting).

Fair is an event held for the presenting or viewing of exhibits, or for recreation. Depending on the theme of the fair, the exhibits may be agricultural, commercial, industrial, or artistic. Some fairs are called *expositions* or *exhibitions*. Small fairs last just a few days and involve exhibitors and visitors from a local area. The largest fairs may run for months and attract exhibitors and visitors from many countries.

There are three basic types of fairs—agricultural fairs, trade fairs, and world's fairs (see **World's fair**). Another type is the *fun-fair* (or amusement park), which sometimes forms part of agricultural or trade fairs.

Agricultural fairs hold contests for the best examples of crops, livestock, poultry, and other farm products. They also organize competitions for various home-produced foods. Companies exhibit and demonstrate agricultural machinery and other equipment. Most agricultural fairs provide amusements and entertainment for visitors.

Trade fairs normally centre on a specific product or industry. For example, a trade fair may confine itself to the computer industry or to book publishing. Generally, trade fairs are intended to provide commercial exposure for the products of the exhibitors. Some of these fairs limit admission only to people within the field covered by the fair. Other trade fairs encourage attendance by the general public. Most trade fairs are held in large exhibition halls in major cities. Fairs are often held in a different city each year.

History. Fairs date back to Biblical times. The book of Ezekiel, which was written in the 500's B.C., has several references to fairs. During the early centuries of Christianity, the church took an active part in sponsoring fairs as part of the observance of religious holidays and seasons. During the mid-1500's, the church stopped participating in and promoting fairs. As a result, fairs lost their religious associations and became events devoted to commercial exhibits and entertainment. In Britain and Ireland, some centuries-old annual fairs have survived to the present day as recreational events.

Fair Isle. See Shetland.

Fair-trade laws were designed to allow manufacturers or distributors of goods to set a minimum resale price, preventing large retail stores from undercutting the price of other shops. Laws of this type were first introduced in the United States, but were later adopted by most major manufacturing countries, where their implementation became known as price, or resale price, maintenance.

Fair-trade legislation was never popular with the United States courts, which tried steadily to erode its effects. Many judges ruled that such laws led to the backdoor introduction of monopolies, in violation of the Sherman Anti-Trust Act of 1890. By the early 1930's, the practice of price maintenance was limited in all interstate transactions to merely suggesting a price. Manufacturers had no power to enforce their suggested selling price. But during the Great Depression of the early 1930's, 45 of the 48 States were forced to introduce limited local fair-trade legislation. The aim was to protect small shopkeepers from total ruin.

Agricultural fairs include contests for the best examples of livestock and other farm products. The cattle, *below*, are being shown at a county show in England.

In countries such as the United Kingdom (UK), which lacked strong anti-trust legislation, the practice of resale price maintenance became widespread in the early 1900's, enforced by trade associations and supported by public opinion. Fair-trade laws were regarded as a method of keeping prices down rather than up. But after World War II (1939-1945), attitudes began to change with the introduction of far more sophisticated marketing methods. Most European countries generally abandoned retail price maintenance in the 1960's, and the United States dropped it in 1975. However, isolated exceptions were made for certain commodities. For example, in the UK, resale price maintenance was maintained, for books only, into the 1990's.

Fairbanks, Douglas, Sr. (1883-1939), was an American film actor who became famous for his acrobatic acting in adventure films. All of Fairbanks' notable movies were silent films. They included *The Mark of Zorro* (1920), *Robin Hood* (1922), *The Thief of Bagdad* (1924), and *The Black Pirate* (1926). Fairbanks' name is still associated with the exaggerated, romantic style of such films.

Douglas Fairbanks, Sr., was a famous film actor of the 1920's. In 1929, he starred with his wife, Mary Pickford, in William Shakespeare's comedy *The Taming of the Shrew, above.*

Fairbanks was born in Denver, Colorado, U.S.A. His real name was Douglas Elton Ullman. For several years, he starred in comedies on Broadway. Fairbanks made his screen debut in 1915. He helped found the United Artists studio in 1919 with actor Charlie Chaplin, actress Mary Pickford, and director D. W. Griffith. Fairbanks married Pickford in 1920.

Fairbanks, Douglas, Jr. (1909-), is an American film actor. His father was Douglas Fairbanks, Sr., a star of silent films. Fairbanks made his screen debut in 1923. He performed in a variety of roles, ranging from romantic heroes to troubled weaklings. His best-known films include *The Prisoner of Zenda* (1937) and *Gunga Din* (1939). He also made several romantic adventure films in the style of his father. They include *The Corsican Brothers* (1941) and *Sinbad the Sailor* (1947).

Douglas Elton Fairbanks, Jr., was born in New York City. After retiring in the early 1950's, he lived mostly in England, where he became a company director and television producer. His autobiography, *The Salad Days* (1988), describes his life to the age of 30.

Fairbanks, Thaddeus (1796-1886), an American, invented the platform scale in 1831. It replaced the large hooks and lifting apparatus necessary for weighing heavy loads.

Fairbanks was born in Brimfield, Massachusetts, U.S.A. He suffered from poor health as a boy, and had little formal education. He established a small iron foundry in St. Johnsbury, Vermont, U.S.A. in 1823, and, over a period of 60 years, made many improvements to such products as ploughs and stoves.

Fairchild, David Grandison (1869-1954), an American botanist and explorer, brought more than 200,000 species of plants to the United States. He helped found the Section of Foreign Seed and Plant Introduction in the U.S. Department of Agriculture, and directed that section from 1906 to 1928. In 1938, Fairchild established the Fairchild Tropical Garden, about 20 kilometres south of Miami, Florida, U.S.A. It became the largest botanical garden in the United States. Fairchild was born in Lansing, Michigan, U.S.A.

Fairchild, Sherman Mills (1896-1971), an American inventor and businessman, was called the "father of aerial mapping photography." He invented many cameras and an automatic photoengraver. Fairchild invented the Fairchild Flight Analyzer Camera in 1953. It was the first camera to take pictures without distortion in a continuous sequence of action. It has been used to track guided missiles and to study the take-offs and landings of missiles and planes.

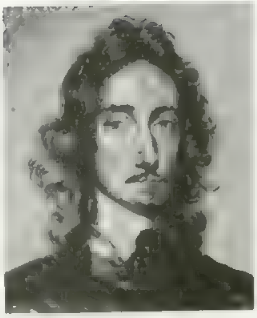
Fairchild developed the FC-1 and FC-2 planes, the first to have enclosed cockpits. He built the C-119 transport plane so that equipment could be rolled in or out of its rear cargo doors. He also developed a radio compass and hydraulic landing gear. Fairchild was born in Oneonta, New York, U.S.A.

Fairfax was the name of two leaders, father and son, of the Parliamentary army in the English Civil War.

Ferdinando Fairfax (1584-1648), Baron Fairfax, became a member of the Long Parliament in 1640 (see **Long Parliament**). At the outbreak of the English Civil War, he took command of the Parliamentary forces in northern England, where he opposed the Duke of Newcastle. He was heavily defeated at the Battle of Adwalton Moor in 1643, when he left the battlefield without warning his fellow officers. He defended Hull stubbornly against Royalist attacks in 1643 and 1644. Fairfax was one of the commanders who left the Battle of Marston Moor (1644), believing that the Royalists had won.

Thomas Fairfax (1612-1671), Baron Fairfax and son of Ferdinando Fairfax, was a Parliamentary cavalry leader. In 1643, he extricated his cavalry safely from the Royalist victory at Adwalton Moor. At the Battle of Marston Moor, in 1644, he attacked the Royalist Army in the rear, a decisive move. Parliament's New Model Army was largely formed and trained by Fairfax, who was appointed its commander in chief. He led the New Model Army to victory at the crucial Battle of Naseby in 1645.

After the capture of Charles I, Fairfax tried to effect a conciliation between the king and Parliament. As a member of the tribunal that tried Charles, he tried unsuccessfully to prevent his execution. In 1650, he refused to lead an army against Scotland and retired from military service. Later, he headed the commission that went to The Hague in 1660 to negotiate the return of Charles II. He was born at Denton, in North Yorkshire, England.



Thomas Fairfax

Fairfax, a well-known Sydney family, has contributed greatly to the Australian publishing industry.

John Fairfax (1804-1877) became coproprietor of *The Sydney Morning Herald* with Charles Kemp in 1841. In 1853, Fairfax bought Kemp's interests in the paper and founded the family partnership.

Sir James Reading Fairfax (1834-1919), son of John, was a public benefactor. He expanded the company and did much to help hospitals and churches.

Sir Warwick Oswald Fairfax (1901-1987), grandson of Sir James, became managing director of John Fairfax Pty. Ltd. in 1930. He became chairman of the newly created public company, John Fairfax Ltd., in 1956.

James Oswald Fairfax (1933-), son of Sir Warwick, became a director of his family's companies in 1957. He became chairman of John Fairfax Ltd. in 1977.

Fairfield, Cicily Isabel. See **West, Dame Rebecca.**

Fairweather, Ian (1891-1974), an Australian artist, was known as a wandering painter of subjects in Bali, India, China, and the islands of the South Pacific. His paintings show his interest in the art of writing Chinese characters.

Fairweather was born at Bridge of Allan, in Scotland. During World War I, he was a prisoner of war in German prison camps. He began his art studies in 1918 in the Netherlands. Later, he studied art at the Slade School in London, and Asian arts and languages at The School of Oriental and African Studies in London. He also travelled widely in Asia. Fairweather settled in Australia in 1943. In 1952, he sailed on a raft from Darwin to Indonesian Timor. On his return to Australia, he made his home in a grass hut on Bribie Island north of Brisbane, where he lived alone and in poverty.

See also **Australian art.**

Fairy is an imaginary creature that appears in the folklore of Western Europe. Fairies have magic powers, which they use to perform both good and bad deeds. Fairies are usually helpful, but they often behave mischievously and occasionally act cruelly.

There are several kinds of fairies, and each lives in a certain area. For example, *brownies, buccas,* and *pixies* live in England; *goblins* in France; *kobolds* and *nixes* in Germany; and *elves* and *trolls* in the Scandinavian countries. Although the word *fairy* generally refers to various characters in Western European folklore, fairylike creatures exist in the folklore of many other parts of the world. Hawaiian folklore includes stories about dwarfs called *Menehune,* who work at night. Japanese folk stories tell of a water demon known as the *kappa.*

Fairies make themselves invisible to human beings. However, some people have the power to see fairies and the places where they live. Sometimes fairies become visible to a person who steps into a *fairy ring.* Fairy rings are dark green circles found in a field or meadow. Fairies enjoy dancing and use fairy rings as places to dance.

Fairies appear in two kinds of folk stories—*legends* and *fairy tales.* Legends take place in the real world, and fairy tales occur in some imaginary land. Legends are told as true stories, but fairy tales are told as fiction. Actually, fairies appear in few fairy tales. Most stories about fairies are really legends.

A number of beliefs and stories about fairies have been popular for hundreds of years. For example, many children believe that the *sandman* comes each night and puts "sleepy dust" in their eyes to help them sleep. The *tooth fairy* replaces a lost tooth that has been placed under a pillow or in a glass of water with some money, while the youngster is asleep. The *bogeyman,* an evil fairy, kidnaps boys and girls who leave home without permission. The *bogey beast,* also called the *bug-a-boo,* carries off children who have been naughty.

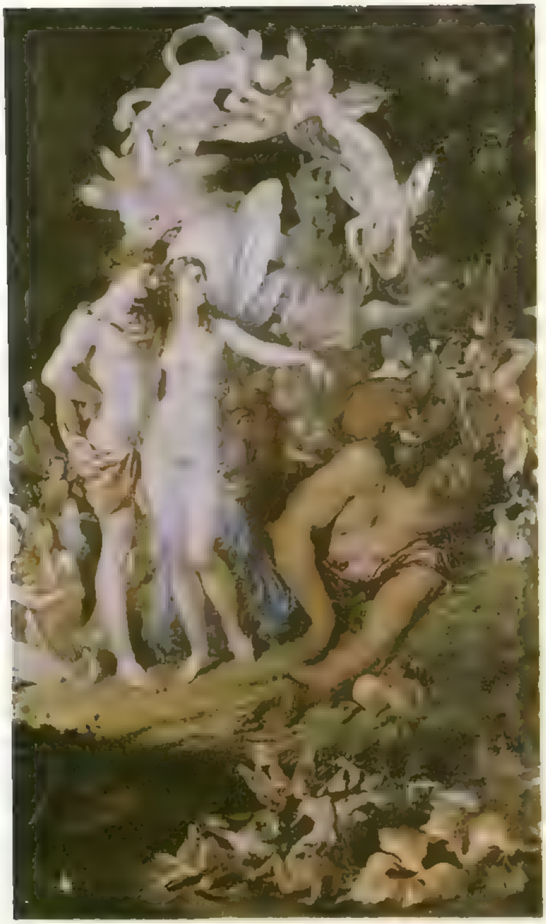
No one knows how the belief in fairies began. In some stories, fairies were angels who were forced to leave heaven because of some wrongdoing. In other stories, fairies were spirits of the dead. Some scholars believe that fairies began as ancient nature spirits, such as the spirits of mountains, streams, and trees. Many stories about fairies represent attempts to explain various happenings. For example, if a cow goes dry, a farmer may blame fairies for stealing her milk.

What fairies look like. Fairies vary in size, but the majority of them are smaller than adult human beings. Most fairies have various human features. Some fairies, including pixies, have great beauty. Other fairies have misshapen faces or deformed bodies. For example, trolls are short, ugly men with crooked noses and humped backs. Irish leprechauns are wrinkled little men. The *banshees,* who live in Ireland and Scotland, have long, streaming hair, and their eyes are fiery red from continual crying. Many fairies wear green or white clothing with red caps. Brownies usually wear brown cloaks and hoods.

Where fairies live. Fairies may live alone or in a large group. The banshee is an example of a fairy that lives alone. In Scotland, she can be heard wailing by a river as she washes the clothes of a person who soon will die. In Ireland, banshees often live near a particular family. The sound of a wailing banshee means that someone in the family will soon die.

Large groups of fairies live in fairyland, a fairy society with its own government and territory. In most stories, a king and queen rule fairyland, with the queen having the most power. Queen Mab is a famous fairy queen in Irish folklore. Oberon is king of the fairies in many legends. Fairyland may be under the earth, inside a hollow hill, or beneath a lake. The entrance may be a door in a hill or under the roots of a tree.

Life in fairyland closely resembles life in the human world. Fairies work, marry, and have children. But time passes extremely slowly in fairyland, and so there is no old age or death. Many legends describe the difference



Detail of an oil painting on canvas (1847) by Sir Joseph Noel Paton; National Gallery of Scotland

The king and queen of the fairies were named Oberon and Titania in many tales. William Shakespeare featured them in his comedy *A Midsummer Night's Dream.*

Detail of a pen and ink drawing (1891) by Henry Justice Ford, National Gallery of Scotland

Rumpelstiltskin was a wicked fairy in German folklore. He spun gold from straw for a girl in exchange for her promise to give him her first child after she married a king. In this picture, Rumpelstiltskin arrives to collect his debt from the girl.

between time in fairyland and time in the human world. In one legend, a man spends what he believes is one night in fairyland. But after he returns to his home, he discovers that hundreds of years have passed—and no one remembers him.

In fairyland, fairies often have trouble giving birth. A common type of fairy legend tells how fairies kidnap a human woman and take her to fairyland to help deliver a baby. The fairies blindfold the woman so that the entrance to the fairy society will remain secret. Fairies nearly always pay the woman well for her help.

Fairies and human beings. People and fairies sometimes marry. A man might go to fairyland to live with his bride, or he might bring his fairy wife back to his home. In many stories, the human being must follow strict rules to remain married to a fairy. For example, a human husband must never scold or strike his fairy wife or refer to her being a fairy. If he does, the fairy immediately returns to fairyland.

Fairies often aid people in various ways. They might help with the housework or with such farmwork as reaping and threshing. In some cases, a person is not allowed to thank the fairy, to offer it gifts, or even to watch it work. If the person breaks one of these rules, the fairy runs away and never returns.

Sometimes fairies reward people for doing them a favour. According to one story, a farmer who mends a fairy oven or chair will receive delicious food in return. Grateful fairies also may leave money for people who have treated them well.

However, fairies are not always helpful and kind. They may steal grain or lead travellers astray. Occasionally, fairies commit cruel acts. In one legend, a woman helps deliver a fairy baby. As she puts some magic ointment on the baby's eye, she accidentally rubs some on one of her own eyes. The ointment enables her to see fairies who are normally invisible to human beings. Later, the woman sees a fairy in a market place and speaks to him. The fairy asks which eye the woman sees him with. After she tells him, he blinds her in that eye.

Fairies sometimes try to trick women into caring for fairy babies. The fairies may exchange their babies, called *changelings,* for healthy newborn human infants. Usually a human mother can see that a changeling has been substituted for her child because the fairy baby has some ugly physical feature or habit. If the mother threatens to burn the changeling, it may leave and give back the woman's own child.

Many people believe in fairies and have developed ways to win the favour of good fairies or to protect themselves from evil ones. Fairies love milk, and so people may pour milk into the ground for them. Parents may hang an open pair of scissors over a child's crib as a charm to prevent fairies from stealing the infant. Parents also may place a cross or a container of holy water beside the baby for protection. If travellers lose their way because of what they believe is a fairy's spell, they try to break the spell by turning a piece of their clothing inside out and burning it.

Fairies in literature. For hundreds of years, authors have written about fairies in novels, plays, and stories. The English playwright William Shakespeare used fairies as major characters in his comedy *A Midsummer Night's Dream.* This play includes Oberon and Titania,

the king and queen of the fairies, and the mischievous fairy Puck. Shakespeare may have based Puck on any of several fairies from British folklore, including *Pooka* of Ireland, *Pwca* of Wales, and *Robin Goodfellow* of England. A fairy named Ariel is an important character in Shakespeare's *The Tempest.* The playwright also wrote a famous description of Queen Mab in the tragedy *Romeo and Juliet.*

In 1697, the French author Charles Perrault published a collection of folk stories called *Tales of Mother Goose.* This book included some stories that are still popular. In one tale, Cinderella's fairy godmother changes a pumpkin into a carriage and mice into horses—and changes them back again. In another story, an evil fairy condemns Sleeping Beauty to death. But a good fairy changes the curse from death to sleep, so a handsome prince can awaken the girl with a kiss. A Russian ballet based on this tale, with music by Peter Tchaikovsky was produced in 1890.

In the early 1800's, two German scholars, the brothers Jakob and Wilhelm Grimm, published a collection of folk stories called *Grimm's Fairy Tales.* Only a few of the stories include fairies. One tale, "Rumpelstiltskin," tells of a fairy who spins gold from straw.

Some authors have made up their own stories about fairies. The Danish writer Hans Christian Andersen wrote several volumes of stories from 1835 until his death in 1875. In one tale, "Little Tiny," the main character springs from a magic flower. The Italian author Carlo Collodi wrote *Pinocchio* (1883), a famous children's novel that has a fairy character. *Peter Pan* (1904), a popular children's play by the English writer J. M. Barrie, has a number of fairies, including Tinker Bell, one of the main characters.

The English author J. R. R. Tolkien included fairies and other imaginary creatures in his works. In *The Hobbit* (1937) and the three-volume *The Lord of the Rings* (1954-1955), Tolkien described a race of wise and gifted elves. They live in the Undying Lands, where nothing ever ages or dies.

Related articles in *World Book* include:

Andersen, Hans Christian	Elf	Grimm's Fairy Tales
Brownie	Folklore	Nix
	Gremlin	

Fairy penguin, also called *little blue penguin,* is the smallest *species* (kind) of penguin found off the southern coasts of Australia and New Zealand. It grows to about 30 centimetres high. Except when nesting and moulting, fairy penguins remain at sea, feeding on squid and fish. They nest on the coast and on offshore islands. They may rear two broods per year. The birds come ashore after dark and leave at dawn.

Scientific classification. The fairy penguin belongs to the penguin family, Spheniscidae. It is *Eudyptula minor.*

Fairy penguin

Fairy tale. See Fairy.

Faisal, also spelled *Feisal,* is the name of two kings of Iraq, grandfather and grandson. They were members of the Hashemite family, which traced its descent from the Prophet Muhammad (see **Muhammad**).

Faisal I (1885-1933) became the first king of Iraq after the British took Iraq from the Ottoman Empire during World War I. He was elected king in 1921, while the country was a British mandate under the League of Nations. Faisal and the British cooperated in overthrowing the ruling Ottoman Turks during the war. The famed Lawrence of Arabia was a close friend of Faisal. Under Faisal's rule, Iraq gained independence in 1932.

Faisal II (1935-1958) became king in 1939 at the age of three when his father, Ghazi I, was killed in a car accident. His uncle, Prince Abdul Ilah, ruled Iraq as regent during Faisal's youth. Faisal II began his reign on May 2, 1953. He and his uncle were killed by revolutionaries on July 14, 1958.

See also **Iraq** (History).

Faisal, also spelled *Feisal* (1906?-1975), was king of Saudi Arabia from 1964 to 1975. He became an important world leader because of his control over Saudi Arabia's vast oil resources. In 1975, Faisal was assassinated by one of his nephews.

Faisal used government profits from oil for such things as industrialization projects and the expansion of public education in Saudi Arabia. During the early 1970's, he brought about an oil embargo against the United States, the Netherlands, and other countries friendly to Israel. He also favoured sharp price increases for petroleum exports.

Faisal ibn Abdul Aziz al Faisal al Saud was born in Riyadh, Saudi Arabia. He was crown prince from 1953 to 1964, and served as prime minister from 1953 to 1960 and from 1962 to 1964 when his brother Saud was king of Saudi Arabia.

See also **Saudi Arabia** (History).

Faith. See **Religion.**

Faiz Ahmad Faiz (1911-1984) was the leading Pakistani Urdu poet of the 1900's. He was born near Sialkot in the Punjab. He graduated from Government College, Lahore, with degrees in English and Arabic. In 1942, he joined the public relations department of the Indian Army. Five years later, he resigned to go to Lahore. From then on, he enjoyed a varied career as a journalist, poet, political activist, trade unionist, film-maker, and broadcaster.

Faiz Ahmad Faiz edited various newspapers and magazines, in English and Urdu. After Pakistan was created in 1947, he was imprisoned several times for his writings and soon became a symbol of protest against oppressive governments. This defiance forced him into long periods of exile in the Middle East.

Faiz's poems have been translated into several languages. He also received many literary awards, including the Lenin Peace prize in 1962 and the Lotus Literary Award in 1983.

Fakir is a Muslim or Hindu man who practises extreme self-denial as part of his religion. *Fakir* is an Arabic word meaning *poor,* especially *poor in the sight of God.* Fakirs usually live on charity and spend most of their lives in religious contemplation. Some fakirs can actually perform such feats of willpower as walking on hot coals.

But they also frequently practise deception. Some fakirs live in religious communities. Others wander about alone. People whose way of life resembles that of fakirs include Muslim *dervishes* and Hindu *yogis*.

See also **Asceticism; Dervish; Yoga.**

Falange Española, also called Spanish Phalanx, was the only legal political party in Spain under dictator Francisco Franco. The Falange Española was founded in 1933 as a fascist group that attempted to overthrow the republic through violence. José Antonio Primo de Rivera, son of former dictator Miguel Primo de Rivera, founded the party. Falangists supported Franco during the Spanish Civil War. In 1937, Franco took control of the party. After 1945, the party was known as the National Movement. In 1977, after Franco's death, the democratic government of Spain abolished it.

Falcon is a type of bird closely related to hawks. Falcons are found in a variety of habitats throughout the world. They live in grasslands, forests, deserts, and Arctic tundras, and along seacoasts. There are about 50 species, half of which are found in Africa. The best-known species include the *peregrine falcon* and the *gyrfalcon*.

Like hawks, falcons have a hooked beak and powerful feet with strong claws. Falcons differ from hawks in having long, pointed wings that curve back in a sickle shape, and beaks that have a "tooth" on each side. Most measure from 20 to 60 centimetres long. Females are larger than males. Falcons are exceptionally powerful fliers. They often make spectacular *stoops* (steep descents) from great heights to capture prey. They use their feet to either grasp or strike at their prey.

Falcons do not build nests. Females lay their eggs in a shallow scrape in the ground, on rocky ledges, in abandoned nests, or in holes in trees, cliffs, or even buildings. They usually lay three to five eggs that are buff or whitish in colour and heavily marked with brown, red, or purple spots or blotches. In most species, the female *incubates* (sits on and warms) the eggs, with regular help from the male. Most falcon eggs require about 30 days of incubation. For the first few weeks after the young have hatched, the male provides nearly all the food for the family. Falcons that survive the first year typically live for 10 years or more.

The peregrine falcon is one of nature's flying marvels. It can stoop for prey at a speed of nearly 320 kilometres per hour. This falcon measures up 50 centimetres long. It is dark blue or bluish-grey above and has white to reddish underparts marked with blackish-brown bars. Peregrine falcons live along cliffs near seacoasts, rivers, and lakes, or in the mountains. They are becoming increasingly rare. These falcons feed chiefly on medium-sized birds such as pigeons.

The gyrfalcon is the largest species of falcon. It grows to a length of about 60 centimetres. It lives in Arctic regions. Most gyrfalcons have white or grey colouring.

Smaller falcons. *Kestrels* are small falcons that *hover* (stay in one place) when hunting for their prey. The *common kestrel* lives in Europe and Africa. It is often seen hovering at the edges of motorways. The American kestrel lives in North and South America. Kestrels eat mostly small mammals and insects. The Mauritius kestrel is one of the world's rarest birds. Only five pairs are left in the wild.

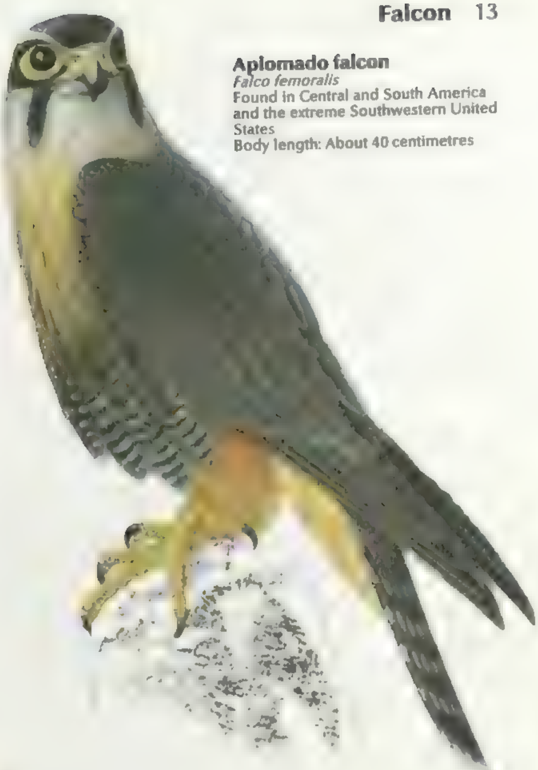
The peregrine falcon dives at speeds close to 320 kilometres per hour. This photo shows a peregrine falcon that has been trained to hunt. The trainer keeps the bird from escaping by holding the *jesses* (straps) hanging from its legs.

Some falcons, like the *hobby* and *Eleonora's falcon*, are very sleek birds with long wings and tails. They fly rapidly and their diet includes many small birds, which they catch in flight. Eleonora's falcon lives on rocky Mediterranean coasts and nearby Atlantic islands. It breeds late in the year and feeds its young on small birds, caught as they migrate from Europe to Africa.

The *merlin* flies low and fast. It also hunts small birds, such as pipits. It lives in upland areas of the Northern Hemisphere. The *sooty falcon* lives in the Middle East and northeast Africa. It is black or grey in colour. It lives in desert areas and feeds mainly on insects.

Peregrine-gyrfalcon hybrids, like the one above, are bred for the sport of falconry. Both peregrines and gyrfalcons are prized for their speed and their breathtaking dives after prey.

Merlin
Falco columbarius
Found in the Northern Hemisphere
Body length: About 30 centimetres



Aplomado falcon
Falco femoralis
Found in Central and South America and the extreme Southwestern United States
Body length: About 40 centimetres

Kestrel
Falco tinnunculus
Found in Europe, Africa, Central and South Asia.
Body length: About 35 centimetres

Gyrfalcon
Falco rusticolus
Found near the Arctic Circle
Body length: About 60 centimetres

The *brown falcon* lives in Australia and southern New Guinea. It is a little smaller than the peregrine falcon. It ranges in colour from dark brown to almost pure white. The brown falcon has a full, rounded tail.

The falcon family also contains the world's smallest birds of prey. These are the pygmy falcons and falconets. The *Philippine falconet* is only about 15 centimetres long. It catches small insects in flight in the treetops.

Scientific classification. True falcons belong to the family Falconidae. The peregrine falcon is *Falco peregrinus;* the gyrfalcon, *F. rusticolus;* the common kestrel, *F. tinnunculus;* the hobby, *F. subbuteo;* Eleonora's falcon, *F. eleonorae;* the merlin, *F. columbarius;* the sooty falcon, *F. concolor;* the brown falcon, *F. berigora;* and the Philippine falconet, *Microhierax erythrogenys.*

See also **Bird** (pictures: Interesting facts about birds; How birds see); **Falconry; Hawk; Kestrel.**

Falconry, once the "sport of kings," is the art of training falcons, hawks, or eagles to hunt game. A *falconer* is a person who hunts with trained birds of prey.

A hunting bird must be tamed, or "manned," and taught to return to the falconer's fist or to a lure. A hood covers the eyes of the bird, keeping it calm. Small bells or radio transmitters are placed on the bird to help locate it when lost. Leg straps called *jesses* restrict the bird's movement when it is on the falconer's hand or perch. A heavy glove protects the falconer's hand.

The ancient Chinese and the ancient Persians independently began the sport of falconry more than 3,000 years ago. Falconry flourished in Europe during the Middle Ages. Each social class was assigned a certain falcon or hawk as a symbol of rank. Kings flew majestic gyrfalcons and serfs flew goshawks. In the 1700's, the wide use of firearms nearly brought an end to falconry.

Falkirk (pop. 139,038) is a local government district in Central Region, Scotland. The town of Falkirk is a thriving centre of light engineering. Other industries include coachbuilding, whisky distilling, and the production of chemicals, clothing, confectionery, electronics components, plastics, and timber. The port of Grangemouth has an important oil refinery. The Romans built the Antonine Wall in A.D. 143, and its ruins still stand. Scottish rebels under Charles Stuart defeated an English army at Falkirk in 1746. See also **Central Region.**

Falkland Islands make up a dependency of Great Britain in the South Atlantic Ocean. The islands lie about 500 kilometres east of the Strait of Magellan (see **South America** (political map)). They form the southernmost British dependency outside the British Antarctic Territory. Argentina also claims ownership of the Falkland Islands. Argentina calls the islands the *Islas Malvinas.*

The dependency includes two large islands, East and West Falkland, and about 200 smaller ones. East Falkland covers 6,682 square kilometres and West Falkland covers 5,278 square kilometres. The climate is damp, cool, and windy.

Most of the approximately 2,000 inhabitants are of British origin. About half the people live in Stanley, the capital and chief town. Stanley is on East Falkland Island.

The Falkland Islands' main source of income comes from the sale of fishing licences to foreign fishing fleets. Many of the islanders raise sheep and export wool. The sale of postage stamps and coins, principally to collectors, also contributes to the economy.

Falkland Islands lie about 500 kilometres off the east coast of South America. The map below shows the main islands of the Falklands.

A governor rules the dependency, aided by an executive and legislative council. The government provides schools, which children must attend. Travelling teachers instruct children in isolated settlements.

The English explorer John Davis sighted the Falklands in 1592. British Captain John Strong first landed on the islands in 1690. He named them after Viscount Falkland, the British treasurer of the navy. France, Spain, and Argentina later laid claim to the islands. British rule was established in 1833, and the Falklands are now an important British base. Argentina has continued to claim the Falkland Islands. In April 1982, Argentine troops invaded and occupied the islands. Air, sea, and land battles broke out between Argentina and Britain. The Argentine forces surrendered in June 1982.

A vast area of islands and ocean became dependencies of Great Britain in 1908. Known as the Falkland Islands Dependencies, they were administered by the Falkland Islands. The principal islands included South Georgia and the South Orkney, South Shetland, and South Sandwich island groups. The South Orkney Islands and South Shetland Islands became part of the British Antarctic Territory in 1962. In 1985, South Georgia and the South Sandwich Islands became a separate dependency in their own right.

Fall line is a line or zone where waterfalls occur on a series of roughly parallel rivers (see **Waterfall**). A fall line occurs where an area of hard rock meets an area of softer rock. Erosion wears away the softer rock faster than the hard rock. As a result, a ledge is formed and swift-flowing rivers create rapids or waterfalls. The edges of plateaus of volcanic rock, such as the Antrim plateau in Northern Ireland, form such ledges. Other fall lines occur where old mountain ranges border coastal plains. One example occurs in the Eastern United States, where the old, hard rock of the Appalachian range meets the younger, softer rock of the Atlantic coastal plain. Another example is the Western Ghats in India.

For many rivers, fall lines mark the furthest point inland a ship can go. Some industrial towns are built near fall lines because a fast-flowing river can be used to generate electricity.

Falla, Manuel de (1876-1946), was a Spanish composer who gained international recognition for his success in developing a modern Spanish style of music. He based many of his compositions on Spanish folklore, folk music, and literary traditions. His best-known work, the music for the ballet *The Three-Cornered Hat* (1919), is based on popular folk music.

Falla's opera *La Vida Breve* won a contest for the best opera by a Spanish composer in 1905, but it was not performed until 1913. His other important works include the music for the ballet *El Amor Brujo* (1915), with its famous "Ritual Fire Dance," and *Nights in the Gardens of Spain* (1916), a composition for piano and orchestra. Falla's puppet opera *Master Peter's Puppet Show* (1923) was based on an episode from the famous Spanish novel *Don Quixote*. *Fantasia Bética* (1920) is his major work for solo piano. Falla was born in Cádiz, Spain. He lived in Argentina from 1939 until his death.

Fallacy is an error in reasoning. Many fallacies appear persuasive and may lead people to false conclusions. *Logicians* (people who study logic) divide fallacies into two main groups, *formal* and *informal*.

A formal fallacy is an argument that has a faulty structure or form. The following incorrect argument is an example of a formal fallacy: Since only children have their pictures in the book, and since John is a child, then John's picture is in the book.

Informal fallacies are errors other than violations of the rules of formal logic. Logicians disagree about the number and kinds of informal fallacies. One informal fallacy, called a *hasty generalization*, is the assumption that what is true of a few cases is true in general. The assumption that what is true of parts is also true of the whole is a fallacy based on a *presumption* or *silent assumption*. A fallacy of *relevance* is an argument in which the truth of the conclusion does not depend on the claims made by the premises.

See also Logic.

Falling bodies, Laws of. Several laws, or rules, tell what an object does when it is allowed to fall to the ground without anything stopping it. These are called the laws of falling bodies. From the time of Aristotle to the end of the 1500's, people believed that if two bodies of different mass were dropped from the same height at the same time, the heavier one would hit the ground first. The great Italian scientist Galileo did not believe this was true. He reasoned that if two bricks of the same mass fall at the same speed, side by side, they ought to fall at the same speed even when cemented together. Therefore, a single brick would fall just as fast as the heavier two bricks cemented together.

Other scientists disagreed with Galileo. According to a popular story, he proved his theory in about 1590 in an experiment at the famous Leaning Tower of Pisa. Galileo is supposed to have gone to the top of the tower with two cannon balls, one large and the other small. He dropped them both at the same instant, and they reached the ground at nearly the same time. There was a small difference, but not nearly so great as the difference between their weights. Galileo concluded that it was the resistance of the air which caused the difference in time of fall between the two cannon balls. Whether or not Galileo actually conducted this experiment, his reasoning about the result was correct.

The dispute was not finally settled until the air pump was invented in about 1650. Then it was shown that if the air were pumped from a long tube, and a feather and a coin were dropped down the tube at the same instant, they would fall side by side and reach the bottom together. The force that draws bodies toward the earth is called *gravity* (see **Gravitation**).

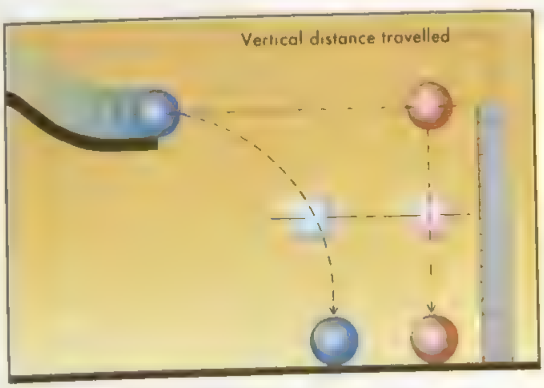
It has been found that this force of gravity acts on all bodies alike, regardless of their shape, size, or density. The earth attracts bodies toward its centre, so all bodies fall in a direct line toward that point. This is the direction called *down*, and it is exactly perpendicular to the surface of still water.

There are three things to consider in studying the laws of falling bodies. One is the *distance* the body travels when it falls. The second is its *velocity*, or speed. The third is its *acceleration*, the rate at which its speed increases as it falls (see **Motion** [Velocity and acceleration]). The abbreviations of these three terms are *d*, *v*, and *a*.

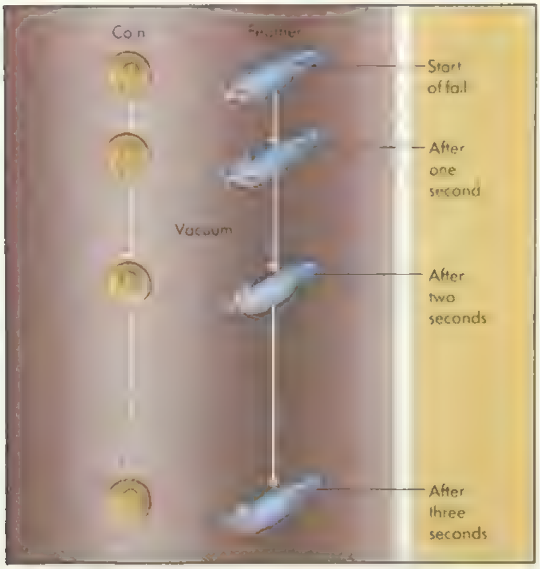
The longer a freely falling body falls, the *faster* it travels. The first law of falling bodies says that, under the influence of gravity alone, all bodies fall with equal acceleration. If the bodies start from rest, and their velocity increases at the same rate, they fall at the same velocity.

Actually, when various kinds of bodies fall through the air, they fall at different velocities. The air *resists* the falling bodies, so they are not falling under the influence of gravity alone. You can test this resistance by dropping two sheets of newspaper, one unfolded and the other crushed into a ball. Both pieces have the same weight, so they give a perfect illustration that the difference of *shape* and not of *mass* causes the difference in the speed at which various kinds of bodies fall.

The acceleration of a falling body is the same for each second. There are no spurts in its "pickup," and its fall is described as *uniformly accelerated* motion. This is true if gravity is the only force acting on the body. Gravity acting on a body that falls from rest *increases* its velocity



Falling bodies descend at the same rate, regardless of horizontal motion, when their fall is caused by gravity. Although the blue ball travels farther than the red ball, they both hit the ground at the same time. The blue ball's horizontal motion, caused by the chute, does not affect its vertical speed.



Bodies falling freely in a vacuum descend at the same speed regardless of their size, shape, or weight. But different objects falling through air may descend at different speeds. This is because objects of different shape meet different amounts of air resistance as they fall.

during *each* second of fall by the same amount of velocity that the body had at the end of its *first* second of fall. The velocity at the end of the first second is 9.8 metres per second (at 40 degrees latitude). The speed of the body increases at a rate of 9.8 metres per second for each second it falls. The body's acceleration is expressed as *9.8 metres per second per second.* This figure is used in most calculations.

At the end of the 1st second $v = (0\,(\text{rest}) + 9.8) =$ 9.8 metres per second.
At the end of the 2nd second $v = (9.8 + 9.8) =$ 19.6 metres per second.
At the end of the 3rd second $v = (19.6 + 9.8) =$ 29.4 metres per second.
At the end of the 4th second $v = (29.4 + 9.8) =$ 39.2 metres per second.

A simple formula for the velocity of a falling body at the end of any second is to multiply 9.8 metres per second per second by the number of seconds the body has fallen.

There is also a simple formula for finding the distance a body falls in a given second. Multiply the distance it falls during the first second by twice the total number of seconds, minus 1. Since the distance fallen during the first second is always 4.9 metres, the distance fallen during the third second is $[(2 \times 3) - 1] \times 4.9 = 24.5$ metres. The distance fallen during the fourth second equals $[(2 \times 4) - 1] \times 4.9 = 34.3$ metres.

By adding the distance fallen during any given second to the distances travelled for all the preceding seconds, you can find the total distance travelled at the end of that given second. For instance, at the end of the third second, a body has fallen 4.9 + 14.7 + 24.5 metres, which adds up to 44.1 metres. Now 44.1 can also be divided up this way: $3 \times 3 \times 4.9$. The total distance fallen in 4 seconds, 78.4 metres, can be divided this way: $4 \times 4 \times 4.9$. So a shorter formula has been worked out which states that the distance a falling body travels in a given time is 4.9 times the square of the time measured in seconds.

The laws just stated can be written in the form of equations. For the velocity at the end of any second:

$$v = 9.8 \times t$$

For distance travelled during any second:

$$d = \left(\frac{9.8}{2}\right) \times (2t-1) = 4.9 \times (2t-1)$$

For total distance travelled at the end of any second:

$$d = \left(\frac{9.8}{2}\right) \times t^2 = 4.9 \times t^2$$

These three equations are true not only for falling bodies, but for any bodies that have uniformly accelerated motion. Any other acceleration, *a*, can be substituted in place of 9.8 metres per second per second. Then we are able to use the more general equations: $v = at$, and $d = \frac{1}{2}at^2$.

Falling sickness is another name for epilepsy. See Epilepsy.

Falling star. See Meteor.

Fallopian tube, also called *oviduct* or *uterine tube,* is either of a pair of female reproductive organs through which eggs from the ovaries pass to the uterus. The fallopian tube is the site where an egg is usually fertilized by the male's sperm. See **Reproduction, Human** (The human reproductive system; picture).

In women, each tube measures about 10 centimetres in length. The tubes are lined with two types of cells, *ciliated cells* and *secretory cells.* The ciliated cells have *cilia* (hairlike structures) on their surface that help carry the egg into and through the tube. The secretory cells produce secretions that nourish the egg.

After entering the tube, an egg must be fertilized by sperm within about 24 hours or it dies. Sperm enter the tube through the uterus, and contractions of the tube help move the sperm toward the ovary. The egg remains in the fallopian tube for about 72 hours before passing into the uterus. An *ectopic pregnancy* occurs when a fertilized egg does not pass to the uterus, but remains in the fallopian tube. Such a pregnancy may be fatal to the baby and mother if untreated.

Blockages in the fallopian tube may result from diseases or birth defects and can cause infertility. In some cases, the blockage can be removed surgically. A woman with blocked tubes may become pregnant through a procedure called *in vitro fertilization.* In this procedure, eggs collected from the ovaries are fertilized in a laboratory dish with sperm and then inserted back into the uterus.

Fallout is radioactive material that settles over the earth's surface following a nuclear explosion in the atmosphere. It consists of atoms known as *radioactive isotopes* or *radioisotopes.* These isotopes form from the *fission* (splitting) of uranium or plutonium in a nuclear weapon or reactor. Radioisotopes also form when radiation that results from an explosion causes other atoms nearby to become radioactive.

After an explosion, the radioisotopes in the air, on the

ground, and in the bodies of living things *decay* (break down) into more stable isotopes. They do so by emitting radiation in the form of alpha particles, beta particles, and gamma rays. Exposure to large amounts of radiation can result in immediate sickness and even death. Exposure to radiation over longer periods can cause cancer and damage genes.

The testing of nuclear weapons in the atmosphere once produced large amounts of fallout. Today, fallout from above-ground testing has been eliminated by underground testing. However, a serious accident in a nuclear reactor can also create fallout.

How fallout is produced. All nuclear explosions produce a giant fireball of intensely hot gases and dust. Everything inside the fireball or in contact with it is *vaporized* (turned into a gas). When an explosion occurs close to the earth's surface, the fireball vaporizes soil, vegetation, and buildings. The intensely hot gases of the fireball also draw in dirt, dust, and other small particles as the fireball rises into the atmosphere. The radioisotopes formed during fission then combine with the vaporized materials. As the vaporized materials rise and cool, some of them condense into solid particles ranging in size from fine invisible dust to ashes the size of snowflakes. These particles, to which radioisotopes have become attached, eventually return to the earth as fallout.

How fallout is distributed. The time it takes fallout particles to settle out of the atmosphere and reach the earth after a nuclear explosion and the distance they travel from the point of origin depend on several factors. These factors include (1) the particles' size and composition, (2) the altitude they reach before they start to fall, (3) the pattern of winds that carry them, (4) the latitude at which the release of radioisotopes occurs, and (5) the time of year.

The larger or heavier fallout particles settle near where they are released in an irregularly shaped area, depending on the winds that carry them. In general, the intensity of radiation decreases as the distance from the point of origin increases. But areas of intense radioactivity called *hot spots* may be scattered within the zone of fallout. Hot spots occur when rain, snow, or other precipitation washes fallout particles out of the atmosphere.

The smaller particles of fallout may be scattered by winds to distant parts of the world. Winds travelling through the *troposphere,* the lowest layer of the atmosphere, carry some fallout for a few days to a few weeks. Winds near the earth's surface change their direction. But in the upper troposphere, winds generally blow in an eastward direction. Fallout carried to this height circles the earth within a week or two. Most of the fallout drops in a band around the earth near the latitude of the fallout's origin.

In the most powerful nuclear explosions, much of the fallout may rise to the *stratosphere,* the layer of atmosphere above the troposphere. There, fallout becomes widely scattered and may take from several months to several years to return to the earth.

The fallout hazard. Fallout can be dangerous to plants, animals, and people because of the radioactive elements it contains (see **Radiation sickness**). These elements include about 200 isotopes of more than 30 chemical elements produced by a nuclear explosion.

The radioisotopes in fallout give off radiation for varying periods. Most fallout radioactivity dies off in a matter of hours or days. As a result, the radioactivity at the end of two weeks is only one-thousandth as strong as the radioactivity one hour after the nuclear explosion. A few of the fallout elements continue to give off radiation over a long period. For example, the radioisotope strontium 90 loses half its radioactive strength every 28 years, and the radioisotope caesium 137 loses half its strength every 30 years (see **Radiation** (Radiation and radioactivity)).

Exposure to radiation created by fallout occurs mainly in two ways. The first type of exposure results from radioactive particles and debris on the ground. People can protect themselves from this direct radiation by taking refuge in underground fallout shelters or by staying in-

Fallout from an April 1986 accident at the Chernobyl nuclear power plant in eastern Europe covered large parts of Ukraine, Belarus, and Russia. The map on the right shows ground contamination by caesium 137, a radioactive form of the chemical element caesium. Amounts of contamination are given in units of radioactivity called curies.

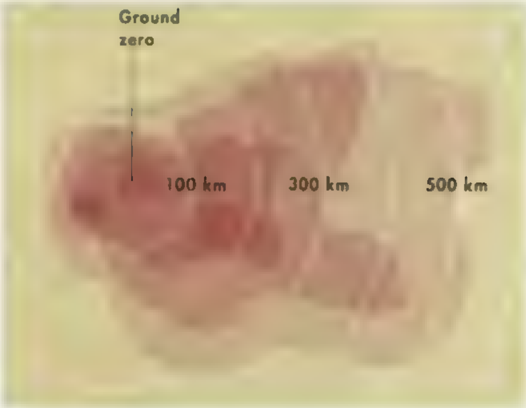
Less than 5 curies per km²

5 to 40 curies per km²

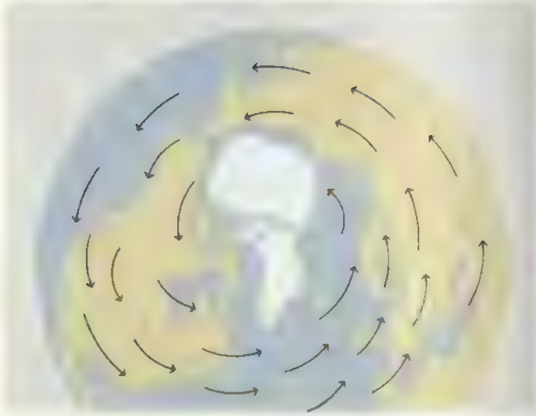
More than 40 curies per km²

0 — 200 Miles

0 — 200 Kilometres



Larger fallout particles settle near where they are released. The reddish areas above indicate relative strength of radiation from a 15-megaton blast. The darkest red areas are "hot spots."



Smaller fallout particles may be scattered far by winds in the stratosphere. The arrows show how fallout from a bomb blast in Chicago would be carried over northern Europe.

doors. A covering of soil or the walls of a building provide protection from fallout.

Second, fallout can enter the body through air, food, or drinking water contaminated by radioisotopes. Normally, radioactive particles do not remain airborne long. Thus, contaminated air is only hazardous for a short time. The transfer of radiation through food occurs over longer periods. A common pathway for the transfer of radioisotopes is through milk. This transfer begins when fallout settles on grass and cows eat the grass. Some of the radioisotopes are then transferred to the cow's milk. Anyone who drinks the contaminated milk takes in iodine 131, which collects in the thyroid; strontium 90, which is absorbed by the bones; or caesium 137, which is retained in muscle or other tissues. Foods are also contaminated by the direct deposit of fallout on plants and by the slow uptake of radioisotopes in soil by the roots of plants.

History. From the mid-1940's to the early 1960's, the United States, the Soviet Union, and a few other nations exploded many experimental nuclear weapons. As a result, fallout increased to alarming levels. In 1963, more than 100 nations, including the United States and the Soviet Union, signed a treaty that banned the testing of nuclear weapons everywhere but underground. Fallout then decreased greatly. China and France did not sign the treaty. But they later stopped testing nuclear weapons above ground.

Today, accidents at nuclear reactors pose the greatest risk of fallout. In 1986, an accident at the Chernobyl nuclear power plant in Ukraine, then part of the Soviet Union, created fallout consisting mainly of the radioisotopes iodine 131 and caesium 137. A power surge caused fuel in the nuclear reactor to overheat, resulting in a steam explosion and fire. The radioisotopes created by nuclear fission in the reactor escaped into the atmosphere through the smoke from the fire, which burned for 10 days.

The fallout from the Chernobyl accident was distributed by winds, but most of the debris remained in the troposphere. Areas that sustained the highest levels of radioactive deposits were in northwest Ukraine, southeast Belarus, and southwest Russia. In addition, precipitation created hot spots throughout the zone of fallout. Radioactive isotopes were carried into northern and central Europe. Traces of radioactivity were eventually measurable throughout the Northern Hemisphere.

The explosion at Chernobyl was the worst in history, but other serious accidents have also occurred. One of the worst happened at the Windscale plutonium production plant in northern England in 1957. Fallout from a fire in a reactor at the Windscale plant contaminated about 520 square kilometres of surrounding countryside. In the United States, an accident occurred at the Three Mile Island nuclear power plant near Harrisburg, Pennsylvania, in 1979. Overheating caused by an interruption in the reactor's cooling system resulted in severe damage to a reactor core. However, a protective building that contained the reactor largely prevented the radioactive debris from being released into the environment.

See also **Civil defence; Isotope; Nuclear reactor; Nuclear weapon; Radiation** (How radiation affects health).

Falls. See **Waterfall.**

False bulrush. See **Cattail.**

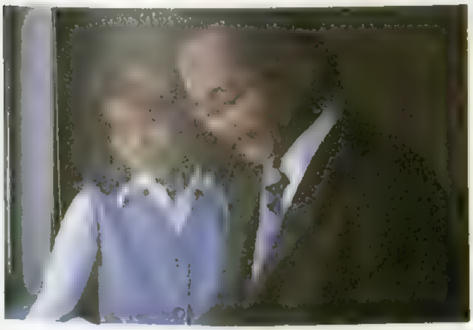
False teeth. See **Dentistry** (Prosthodontics).

Falstaff, one of the best-known characters in the plays of the English playwright William Shakespeare, appears in the two parts of *Henry IV* and in *The Merry Wives of Windsor*. His death is reported in *Henry V*. Falstaff's fat, ungainly figure, his wit, and his human weaknesses make him a lovable and pathetic character. But his boastfulness, cowardliness, and self-indulgence are serious failings. When Prince Hal, Falstaff's friend, becomes king, he realizes that a king should not associate with such a man, and he rejects Falstaff. But, in doing so, he rejects much that is human.

Family, in biology, is a unit of scientific classification. Organisms are classified in seven major groups called kingdoms, phyla, classes, orders, families, genera, and species. Members of a family are more closely related than members of an order, but not so closely as members of a genus. See also **Classification, Scientific** (table).

A single-parent American family

A nuclear Russian family



A childless Chinese couple

An extended Namibian family

People of all known cultures live in family groups. Such groups range from two people to *extended families,* in which grandparents, parents, and children share a home. The most common family unit is the *nuclear family,* consisting of a mother, a father, and their children.

Family is one of the oldest and most common human institutions. Since prehistoric times, the family has been an important organization in society. Most people grow up within a family and, as adults, establish a family of their own.

The term *family* commonly means a group of related people who share a home. The word *family* also refers to all a person's ancestors and other relatives. Most families are based on *kinship*—that is, the members belong to the family through birth, marriage, or adoption. However, some groups that are not based on kinship think of themselves as a family because they share a home or feel ties of affection. For example, foster children and their foster parents are not related by adoption, birth, or marriage. But they live together and consider themselves a family.

In most industrialized Western countries, the typical family consists of a mother, a father, and one or two children. However, there are many other types of family structures. The smallest family unit consists of two persons, such as a parent and child or a couple who share a home and companionship. When a couple have children, the parents and their children make up a *nuclear family.* If married children and their offspring live with the parents, the family is called an *extended family.* An extended family's household might also include aunts, uncles, and cousins. Such relatives, along with grandparents, grandchildren, and others, form part of an extended family group even if they live in separate homes. Some cultures recognize a large kinship unit called the *clan.* A clan consists of all people who are descended from a common ancestor through their mother's or father's side of the family.

The family fulfils many important functions in society, but the kinds of functions vary from one culture to another. In most societies, the family is the social unit into which children are born. The family also provides protection and training for the children. Human beings are born helpless and need care for several years after birth. Family life also helps children become familiar with the culture of their society.

The family provides economic support for its members. Commonly, the adults receive income from jobs, investments, public welfare, or other sources. This money is then shared with the other members of the family. In some cases, the family functions as a group to

make a living. All family members work together at farming or some other economic activity. The family may also be a means of preserving property. The children become heirs to their parents' land and other wealth. One function of the family in industrialized societies is to meet certain emotional and social needs of family members. Each member is expected to provide the others with affection, emotional support, and a sense of belonging.

This article deals mainly with families that share a household. It concentrates on families in Western, industrialized countries whose economies are based on capitalism.

Family relationships

People are related to one another by *blood* (through birth), by *affinity* (through marriage), or through adoption. Most nuclear families consist of a mother, a father, and their *biological children* (the children born to them). Many other nuclear families have members who are included through adoption or remarriage. When a couple adopt a child, the child becomes a member of their family. The adopted child gains all the legal rights of a member of that family. When a divorced or widowed parent remarries, the parent's new *spouse* (husband or wife) becomes the children's *stepfather* or *stepmother.* The children become the new parent's *stepchildren.* Children from the couple's previous marriages become *stepbrothers* and *stepsisters* to one another. *Half brothers* and *half sisters* share either the same biological mother or the same biological father.

The parents of a person's mother or father are that person's *grandparents. Great-grandparents* are the parents of a person's grandparents. An *aunt* is the sister of a person's mother or father. An *uncle* is a parent's brother. An uncle's wife is also called aunt, and an aunt's husband is also called uncle, but they are not a person's blood relatives. A *first cousin* is the child of a person's aunt or uncle. The child of a first cousin is a person's *first cousin once removed.* Children of first cousins are *second cousins* to each other, and children of second cousins are *third cousins.* The child of a second cousin is a person's *second cousin once removed.*

Touring places of interest is a popular family activity throughout the world. In Thailand, many families enjoy visiting their country's beautiful temples, such as this one in Bangkok.

When people marry, they gain a new set of relatives, called *in-laws.* The mother of a person's spouse is called a *mother-in-law,* the brother is called a *brother-in-law,* and so on throughout the rest of the family.

Some families consider certain friends as family members because they feel special affection for them. Such friends are *fictive kin,* and family members might call them by family names. For example, children might call their parents' best friends "aunt" and "uncle."

Almost all societies prohibit *incest*—that is, marriage or sexual relations between certain relatives. They especially forbid sexual relations between all members of a nuclear family except the husband and wife. Most societies also prohibit marriage between such relatives as grandparent and grandchild or uncle and niece, and some extend the ban to first cousins.

Family living

In many industrialized countries, people are increasingly turning away from traditional family patterns. They are adopting new roles for family members and various kinds of family structures. Many of these changes reflect scientific, economic, and social developments and changing attitudes. For example, modern birth control methods enable couples to limit the size of their family and to space their children. Many young people are postponing marriage and childbearing, and many couples want to have fewer children than people had in the past.

The number of employed married women has been growing dramatically in industrialized countries. In the United States, for example, the percentage of married women who work outside the home has risen from about 15 per cent in 1940 to about 55 per cent today. This increase has led to many changes in family life. It has contributed to the ideal of the *equalitarian family,* in which each member is respected and neither parent tries to be the head of the family.

Divorce has become more and more common. In the United States, statistics indicate that about half the marriages that took place during the 1970's are likely to end in divorce. In the United Kingdom, the divorce rate more than trebled between 1968 and 1987. But divorced people often remarry. This fact suggests that many divorced people have not given up on family life. Instead, they believe they can find happiness in marriage with a new partner.

Home life. The home is the centre of family activities. These activities include caring for the children, playing games, watching television, housekeeping, and entertaining friends. In the home, children learn basic social skills, such as how to talk and how to get along with others. They also learn health and safety habits there. In addition, family meals can be a major source of nutrition for family members.

A family's home life is influenced by which members live in the home and by the roles each member plays. Home life can also be affected by relatives who live outside the family's home. Traditions, laws, and social conditions help determine who lives in a home and the place each family member holds.

Traditions, which are based on a family's cultural background, strongly influence family life. Families can differ on account of their cultural heritage. For example, some people have little contact with relatives outside the nuclear family. But many others—especially those who belong to such cultural groups as the Chinese, Indians, Hispanics, and West Indians—feel strong ties to such relatives and see them often. Aunts, uncles, and cousins traditionally are important in the lives of these people.

Laws regulate family behaviour in various ways. Generally, these laws set forth the legal rights and responsibilities people have as husbands, wives, parents, and children. The laws forbid abuse of children by parents, and of one spouse by the other. Family laws also deal with marriage, divorce, and adoption.

Social conditions can affect family life in many ways. For example, black men have sometimes been discriminated against in getting well-paying jobs in some countries. Thus, black wives have been more likely than white wives to work outside the home in those countries, to help support the family. As a result, many of those black wives have tended to have more authority in family affairs than have the white wives.

The nuclear family, consisting of a husband, a wife, and their children, is considered the traditional family in many industrialized countries. As husband and wife, the couple hope to share companionship, love, and a sexual relationship. As parents, they are required by law to feed, clothe, shelter, and educate their children.

Children depend on their parents for love and the basic necessities of life. The children, in turn, give emotional support to their parents and to their brothers and sisters. As the children grow older, they may be given various household chores. Most grown children eventually leave their parents' home.

Traditionally, the father is required to support his wife and children. The mother is expected to run the home and care for the children. In many families, the father alone makes the major family decisions and is considered the head of the family.

Today, however, many people are turning away from these traditional family roles and toward an equalitarian relationship. The parents make family decisions together. They hold the authority in the family but try to consider the children's opinions. The children may express their desires and opinions, and they have much freedom within the family. In most such families, both parents probably work outside the home. The father may help out more in taking care of the children. The father and children may share in chores that were traditionally performed by the mother alone, such as washing clothes, cleaning the house, and cooking.

Other family patterns. Not all people choose to marry and live in a nuclear family. For example, some married couples decide not to have children. Also, some couples *cohabit* (live together without marrying). They want the companionship of another person but, for various reasons, prefer not to marry. Some such couples have children and live as a nuclear family, and some cohabiting couples eventually do marry. Although an increasing number of couples are deciding to cohabit, some people object to cohabitation because it conflicts with their moral standards.

In some cases, divorced or widowed parents choose not to remarry. Instead, they and their children live together as a *single-parent family.* In most cases of divorce, the children stay with their mother, but they may visit their father regularly. A judge might require the father to help support his children. However, more divorced fathers are sharing with the mother custody of their children. In many such cases, working mothers must contribute to their children's support. Increasingly, never-married fathers and mothers are deciding to raise their biological or adopted children in a single-parent family. In some families, children of single mothers are raised by their grandparents.

Some groups of people live together as *communal families.* The members of a communal family might include married and unmarried couples, single adults, and children. They might share child care, housework, and living expenses.

Family problems. Almost every family has problems as a normal part of living together. Many problems can be worked out in the home. But some problems are difficult to solve. Unsolved problems may result in unhappiness and lead to a breakdown of the family.

The question of divorce can be one of the most serious problems a family may face. Divorce can affect every member of the family deeply. The husband and wife must make a new life for themselves, and the children may grow up in a fatherless or motherless home. Today, divorced women and their children make up an increasing proportion of the poor. But many experts believe that living with only one parent may be better for children than living with both parents in an unhappy home.

Couples get divorced for numerous reasons. One of the main reasons is that they expect a great deal from family life. Many people expect the family to be a constant source of love and personal satisfaction. However, family members spend much of their time at work, in school, and at other places outside the home. Thus, they have limited time together to give one another emotional support. Their experiences outside the home affect their behaviour in the family. They might not always feel as loving as they are expected to be.

Other problems may result from remarriages by divorced or widowed people. Such remarriages create the *blended family* of wife, husband, and each of their own children. Quarrels between the new couple over their children are sources of conflict and new divorces. Children naturally have mixed feelings about their new family. They become painfully certain that their biological parents will not be reunited. Children who were very close to the single parent may feel displaced and jealous because the stepparent has a special and private relationship with their parent. Children also may feel fondness and love for their new family but be scared that the new marriage also will end in divorce or death. In addition, children may see their feelings of love as a mark of disloyalty to the absent parent.

The rights and obligations between stepparent and stepchildren may seem different than those taken for granted between biological parents and children. Parents may recognize such differences, for example, in their right to discipline. Thus, stepparents and children are generally challenged to deal with many feelings that are not present in biological families.

Treatment of family problems. Many families can receive help with some of their problems by consulting a trained family counsellor, a member of the clergy, a social worker, or a psychologist. Many such specialists use a technique called *family therapy.* They meet with the entire family as a group to help them work out their problems together. Various public welfare agencies offer guidance and economic aid. Other organizations counsel family members who have a specific problem. There are also groups to aid runaway children or battered children and wives.

Many people tend to view the family as separate from society. They think all family problems can be solved by dealing only with the family. They fail to realize that the family is part of society and that society influences family life. Such social problems as drugs, poor housing, and unemployment directly affect family life.

Increasingly, sociologists are finding that alcoholism, child abuse, runaway children, unhappy marriages, and certain other family problems are related to problems in society. They believe that such family problems can be reduced by dealing with the social conditions that help promote them. For example, programmes that create new jobs, improve housing, or restrict drug trafficking help support family life. With the existence of such programmes, the family is no longer solely responsible for overcoming all the social problems that affect it.

History of the family

Early families. Scientists believe that family life began among prehistoric people more than 300,000 years ago. It may have developed because of the infant's need for care and the mother's ability to nurse the child.

The earliest prehistoric people probably lived in groups made up of several families. They moved from place to place, hunting animals and gathering wild plants for food. Everyone worked for the survival of the group by searching for food. At first, the early people hunted small animals. In time, they developed the means to kill or capture large animals. Some researchers think that the hunting of large game eventually led to a division of labour between men and women. Such hunting required the hunters to be away from the camp for hours or days. The women probably found such hunting difficult during pregnancy and, after giving birth, stayed near home to nurse their young. But the men could go off to hunt large game. The women probably gathered plants and hunted near the camp.

The division of labour between men and women may have helped the men gain power within the family. In many cultures, the women raised crops, and the men turned from hunting to the herding of goats, sheep, and other animals. A family's wealth depended on its herd because the animals provided a steady source of food and could also be traded for other goods. The father controlled the family's herd and thus its wealth. This control gave the father economic power within his family, and he came to be considered the head of the family. A family in which the father has the most power is called a *patriarchal family.*

Patriarchal families were common in early civilizations. Among the ancient Hebrews, who lived in the Middle East during Biblical times, the father had the power of life and death over his wife and children. He also controlled the family's property. Strong patriarchal societies also existed in ancient China, Egypt, Greece, and Rome and among Hindu people in India.

The family in Western culture developed from the traditions of the ancient Hebrews and other patriarchal societies. The father remained the most powerful figure in the family. The nuclear family was common throughout history. But some households included other relatives, servants, or an apprentice, who lived with the family and learned the father's trade.

Until the Industrial Revolution began in the 1700's, most of the people of Europe lived in rural villages or small towns. Families produced their own food and made most of their clothing, furniture, and tools. Most manufactured goods were produced under the *domestic system,* also called *cottage industry.* Under this system, an entire family worked together in the home to make clothing, textiles, or other products for market.

A family of the early 1900's made artificial flowers in their home to sell, *left.* Working as a group to earn a living was an important function of the family everywhere before the Industrial Revolution began in the 1700's. But by the time this photograph was taken, few families in industrial societies still worked together at home to support themselves.

Pioneer families of America and Australia worked together to clear the land and to plant, cultivate, and harvest crops. At about 6 years of age, children had to begin doing chores to help the family. Many settlers wanted, and needed, a large family to help with the many tasks of daily life. In addition, older children could hunt and help protect the family against wild animals, fire, and other dangers.

In rural societies, the family also served as a centre of education, religious instruction, health care, and recreation. Girls learned how to cook, sew, spin, and weave from their mother. Boys learned farming or a trade from their father or were apprenticed to a skilled worker. In many families, the children also received religious training from their parents. Old, orphaned, and sick relatives were cared for in the home. In addition, much of a family's social life took place there. For example, family members might gather in the evening for games or conversation or to entertain other families in the neighbourhood.

In Western societies, the family served as a means for passing land and other wealth from one generation to the next. Commonly, property was inherited through the male line. Families hoped for sons, who would carry on the father's name and inherit his property.

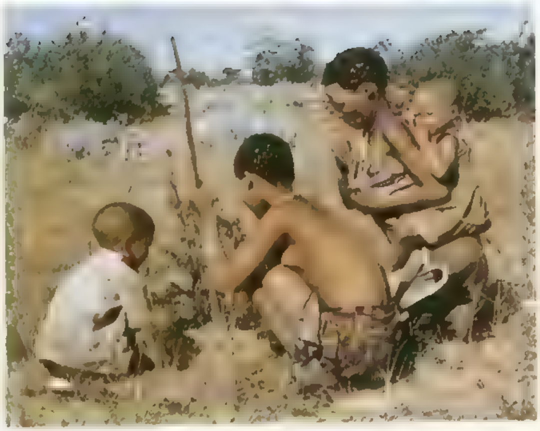
As Western countries became increasingly industrialized, many rural people moved to the cities to seek factory work. Family life in the city differed from that in rural areas because people had to leave home each day to work. Commonly, the mother and children also held a job to help support the family. Family members had little time together, and the home became less central to family life. Hospitals, schools, and other social institutions took over many family functions. In addition, families could look to the police and fire brigade to help protect their lives and property.

Traditional families in other cultures. Most early non-Western civilizations probably also had a patriarchal family system. Some may have had an *equalitarian system,* which gave women and men equal power in the family. Researchers have found no evidence of a truly *matriarchal system,* in which the mother headed the family and held the most power in society. But in some cultures, the mother was especially honoured.

Throughout history, most Western and non-Western societies have practised a form of marriage called *monogamy.* Monogamy means a person has only one spouse at a time. But many other cultures, especially non-Western ones, have permitted *polygamy.* Polygamy allows a person to have more than one spouse at a time. There are two kinds of polygamy, *polyandry* and *polygyny.* Polyandry permits a woman to have more than one husband at a time, and polygyny allows a man more than one wife.

Today, many people in non-Western cultures follow family patterns that are probably similar to those their ancestors practised centuries ago. Most such traditional families live in remote rural areas. The following discussion describes some non-Western family patterns of the past and the present.

Hunter and gatherer societies still exist among the Pygmies and San of Africa, among various groups of Inuit, Australian Aborigines, and South American Indians; and among certain other peoples. The people live in groups of about 20 to 200 members. The nuclear family is the main family structure in many groups, but some groups live in extended families. The men hunt, and the women gather wild plants. The women also practise, and probably invented, such crafts as weaving, basketry, and pottery making.



San families in southwestern Africa live much as their ancestors did centuries ago. The women and young children gather wild plants for food, *above,* and the men hunt.

The Chinese. From ancient times to the mid-1900's, the Chinese worshipped their ancestors and felt great loyalty to their father's clan. The family was a strong patriarchal unit, and women had little freedom. The father decided whom his children should marry. Commonly, a bride went to live in her in-laws' home. She was considered an outsider because she came from another clan. The only way she could gain respect was to bear many sons and so increase her husband's clan.

In 1949, the Communists gained control of China's government. They began a programme to make China a strong, industrial country. As part of the programme, the Communists tried to do away with many of the ancient family customs. Today, many Chinese people live in nuclear families much as do people in other industrial countries.

The Muslim Arabs have had an extended, patriarchal family system for centuries. Family ties are extremely strong, and many related families commonly live near one another. The culture allows polygyny, but few men practise it. Women have little freedom and live in separate women's quarters in the house. If a husband divorces his wife, their children remain in his home.

Increasingly, the family patterns of some Muslim Arab communities are changing and coming to resemble those of Western cultures. This change is most common in the large, industrial cities, where the people are exposed to Western ideas.

North American Indians practised a wide variety of family customs before white settlers arrived. After the Indians were forced onto reservations, most tribes tried to keep their family customs. However, more and more individuals turned away from their traditional way of life and adopted family patterns of the white American culture.

Some tribes, such as the Hopi of the Southwestern United States, still follow their traditional way of life. To the Hopi, women are the centre of family life. The oldest woman is honoured as the head of the family, but her brother or maternal uncle commonly holds the most authority in the family.

In many cases, a woman shares her home with her unmarried children and her married daughters and their families. A husband lives in his wife's household. But he considers his mother's or his sister's house as his home and often returns there for family ceremonies.

Children are considered part of their mother's *line,* or ancestral family. The mother's brother, as a member of her line, has the most authority over her children. Her husband gives his children love but has little authority over them. Instead, he disciplines and has authority over his sisters' children.

Related articles. See the *Way of life* or *Family life* section of various country articles, such as **Mexico** (Way of life). See also the articles on groups of people, such as **Indian, American** and **Inuit.** Other related articles in *World Book* include:

Children

Adolescent	Baby	Growth
Adoption	Child	

Family life through history

Egypt, Ancient (Family life)	Greece, Ancient (Family life)	Prehistoric people
		Rome, Ancient (Family life)

Family needs

Clothing	Food	Nutrition
Cooking	Housing	

Parents

Divorce	Guardian	Parent
Foster parent	Marriage	

Other related articles

Birth control	Community	Health
Budget	Cousin	Polygamy
Clan	Genealogy	Tribe

Outline

I. **Family relationships**

II. **Family living**
- A. Home life
- B. The nuclear family
- C. Other family patterns
- D. Family problems
- E. Treatment of family problems

III. **History of the family**
- A. Early families
- B. The family in Western culture
- C. Traditional families in other cultures

Questions

What is a *patriarchal family*?

How was family life affected as Western countries became increasingly industrialized?

What responsibilities do parents have toward their children?

How are *second cousins* related to each other?

What is a *nuclear family*? An *extended family*?

Who are *in-laws*?

What are some functions the family fulfils in society?

What are some reasons for the changes in traditional family patterns?

What is an *equalitarian family*?

How do some researchers think the division of labour between men and women developed in prehistoric times?

Family name. See Name.

Family planning. See **Birth control.**

Family tree. See Genealogy.

Famine is a prolonged food shortage that causes widespread hunger and death. Throughout history, famine has struck at least one area of the world every few years. Most of the developing countries of Africa, Asia, and Latin America have barely enough food for their people. Approximately half a billion people throughout the world are seriously malnourished, either from eating too little food or from eating the wrong sorts of food. When food production or the import of foodstuffs drops, famine may strike and thousands or millions of people may die.

Causes of famine

Many famines have more than one cause. For example, the great Bengal famine of 1943 in eastern India was caused by both historical and natural events. World War II (1939-1945) created a general food shortage and led to the cutoff of rice imports from Burma, which was occupied by the Japanese. Then a cyclone destroyed much farmland in the area. Famine struck, and more than $1\frac{1}{2}$ million people died.

Nearly all famines result from crop failures. The chief causes of crop failure include (1) *drought* (prolonged lack of rain), (2) too much rainfall and flooding, and (3) plant diseases and pests. Many other factors may also help create a famine.

Drought ranks as the chief cause of famine. Certain regions of Africa, China, and India have always been those hardest hit by drought and famine. All three have large areas that border deserts, where the rainfall is light and variable. In a dry year, crops in those areas fail and famine may be the result. In the 1870's, for example, dry weather in the Deccan plateau of southern India caused a famine that took about 5 million lives. During the same period, a famine in China killed more than 9 million people.

In the late 1960's and early 1970's, lack of rain produced widespread famine in a region of Africa called the Sahel. The Sahel lies just south of the Sahara. It includes parts of Senegal, Mauritania, Mali, Burkina Faso, Niger, Nigeria, Chad, and Sudan. Some geographers consider dry regions of Ethiopia, Kenya, and Somalia to be part of the Sahel. Famine again struck this part of Africa and parts of southern Africa during the mid-1980's. The famine was also especially devastating in Ethiopia, where a civil war hampered relief efforts. Since the late 1960's, millions of Africans have died of malnutrition or hunger-related causes. But many have been saved by international assistance.

Too much rainfall may also bring famine. Rivers swollen by heavy rains overflow their banks and destroy farmland. Other crops rot in the field because of the excess water. In the 1300's, several years of heavy rains created widespread famine in western Europe. The Huang He River in northern China is called *China's Sorrow* because it often floods, ruining crops and bringing famine. In 1929 and 1930, flooding along this river caused a famine that killed about 2 million people. In 1989, flooding in Sudan, Africa, caused widespread damage and famine.

Plant diseases and pests sometimes produce famine. During the 1840's, a plant disease destroyed most of Ireland's potato crop. Between 1841 and 1851, Ireland's population dropped by about $2\frac{1}{2}$ million people

Famine victims receive food and other emergency aid from their government and such international agencies as the Red Cross and the United Nations (UN). These people are victims of a famine that struck Ethiopia in the mid-1980's.

through starvation, disease, and emigration. From time to time, swarms of locusts cause widespread destruction of crops and vegetation in the Sahel and other areas of Africa.

Other causes of famine include both natural and human ones. Such natural disasters as cyclones, earthquakes, early frosts, and tidal waves may affect a large area, destroying enough crops to create a famine. War may result in a famine if many farmers leave their fields and join the armed forces. In some cases, an army has deliberately created a famine to starve an enemy into surrender. The army destroys stored food and fields of crops and sets up a blockade to cut off the enemy's food supply. Blockades prevented shipments of food from reaching the region of Biafra during the Nigerian civil war (1967-1970). A famine resulted, and it is estimated that more than a million Biafrans starved.

Poor transportation may also contribute to a famine because of the difficulty of shipping food to where it is most needed. Many famines result largely from primitive transportation systems. A famine in what is now the state of Uttar Pradesh in northern India killed about 800,000 people in 1837 and 1838. Lack of transportation prevented the shipment of grain from other areas of India.

Effects of famine

The chief effects of famine include (1) death and disease, (2) destruction of livestock and seed, (3) crime and other social disorders, and (4) migration.

Death and disease are the main and most immediate effects of famine. People who lack sufficient food lose weight and grow extremely weak. Many famine victims become so feeble that they die from dehydration caused by diarrhoea or some other ailment. The weakened condition of a starvation victim is called *marasmus.* Old people and young children are usually the first to die.

Children who have some food but do not receive enough protein develop a condition called *kwashiorkor.* One of its symptoms is *oedema* (puffy swelling of the face, forearms, and ankles). Changes in the colour and texture of the hair and skin also may occur. Young victims who do not die from kwashiorkor or starvation may grow up with severe mental and physical handicaps.

Famines also increase the possibility of epidemics. Cholera, typhus, and other diseases take many lives because people weakened by hunger do not recover easily from disease. Large numbers of the victims have fled from their homes and live in crowded refugee camps where disease spreads quickly. People frequently must drink impure water, which can carry disease.

Destruction of livestock and seed during a famine prolongs the disaster. Many farm animals die or are killed for food. Farmers, to avoid starvation, may have to eat all their seed before the planting season begins. Such damaging losses hinder them from returning to a normal life and may lower production levels.

Crime and other social disorders increase during a famine. Such crimes as looting, prostitution, and theft multiply. Desperate people steal food and other items they could not obtain otherwise. They may sell stolen goods to buy something to eat. There may be scattered outbreaks of violence, particularly near food distribution centres.

Migration. Large numbers of famine victims leave their homes in rural areas and flock to cities or refugee camps where food may be available. In the confusion, parents and children may become separated.

Prolonged famine may result in emigration. The potato famine in Ireland caused about a million people to emigrate to other countries, in particular the United States.

Fighting famine

The United Nations (UN) and several other international organizations provide emergency help for famine victims. Various agencies also work to increase the world's food supply and thereby prevent future famines. Many countries hope to prevent famine by increasing their food production. If a country can build up a large enough reserve of food, regional crop failures will not cause disastrous shortages. For additional information about world food programmes and methods of producing more food, see the *World Book* articles on **United Nations** (Fighting hunger) and **Food supply** (Methods to increase the food supply; Food supply programmes).

If a country's population grows as fast as its food production, little food will be left over to build up a reserve. For this reason, many countries have promoted birth control programmes to limit their population growth (see **Birth control.** However, such programmes have had limited success in areas where large numbers of people remain poor. Many poor people want large families so the children can help with the work and, later, care for the parents.

Fan. Long ago, people learned they could make themselves feel cooler on hot days by waving a leaf through the air and creating an artificial breeze. The early Assyrians and Egyptians used hand fans made of palm leaves. Wealthy people had servants to fan them with huge leaves. Fans were also used to brush flies from sacred vessels in the Christian church from about A.D. 300 until about 1300.

A French fan from the 1800's is decorated with a winter scene. It is made of paper, silk, lace, and mother-of-pearl.

Historians believe that the folding fan was invented in Japan in about A.D. 700. The inventor may have made the fan after noticing the way in which a bat folds its wings. Japanese artists often painted fans with bright colours and used them in ceremonial dances.

The Chinese soon began using the folding fan, and in the 1500's the Portuguese brought it to Europe. European women adopted and used painted fans. For a short time, during the reign of Louis XV of France, men also carried dainty folding fans.

In the 1800's, noted artists painted fans which sold for a lot of money. They made the more expensive ones from asses' skin, parchment, or silk. They also made fine fans from lace, gauze, ostrich feathers, and peacock feathers. They mounted the fans on beautifully carved handles of ivory, tortoise shell, horn, bone, or sandalwood.

As a device for keeping cool, the electric fan has largely replaced the hand fan.

Faneuil, Peter (1700-1743), a merchant of Boston, Massachusetts, U.S.A., built Faneuil Hall for the city as a public market and meeting place. It was completed in 1742. Fire gutted the hall in 1761, and repairs were completed in 1763. Faneuil Hall now houses historical paintings, a library, and a military museum. A huge grasshopper weathervane on top of the building has become a Boston landmark. The hall became known as the *Cradle of Liberty* because of the historic meetings held there during the American Revolution and the American Civil War. Faneuil was born in New Rochelle, New York, and moved to Boston at the age of 12 to live with an uncle. He inherited his uncle's fortune in 1738.

Fang. See **Dog** (Body structure); **Snake** (Fangs and venom glands; diagram); **Spider** (Chelicerae).

Fanon, Frantz Omar (1925-1961), was a political theorist who became a leader of Algeria's struggle to gain independence from France. A black West Indian, he also supported other African independence movements and helped strengthen ties between Arabs and African black nationalists.

Fanon was born in the French colony of Martinique, in the French West Indies. As a young man, he studied psychiatry and medicine in France. He later worked in a hospital in Blida, Algeria. In 1956, Fanon joined the Algerian independence movement. For a time, he represented the movement as a diplomat in Ghana.

Fanon's first book, *Black Skin, White Masks* (1952), is a psychological study of the problems black people face because of racism. In *L'An V de la révolution algérienne* (1959)—published in English in 1965 as *Studies in a Dying Colonialism*—Fanon described the Algerians' struggle for independence both as a social revolution resulting in changes in society and as a nationalist movement. Fanon's book *The Wretched of the Earth* (1961) made him famous. In it, Fanon argued that Algerians could achieve independence only through violent revolution.

Fantasia is an instrumental musical composition that has no fixed form or style. Instead, it depends on the composer's imagination.

Some fantasias are written in such a free style that they sound as though the performer is making up the composition as he or she plays. Such fantasias are composed mainly for organ or piano. In the 1700's, Johann Sebastian Bach and his son Carl Philipp Emanuel were masters of this type of fantasia. Another type, called a *fantasy piece,* is a short, dreamlike composition. Robert Schumann wrote many fantasy pieces. Longer fantasias resemble a sonata, but they are much freer in form. Schumann, Franz Schubert, and Frédéric Chopin composed a number of longer fantasias in the 1800's. In England during the 1500's and 1600's, composers wrote pieces for instrumental ensembles that were called fantasias or *fancies.*

Fantasy. See **Literature for children** (Fiction).

FAO. See **Food and Agriculture Organization.**

Far East is a term that is sometimes used for the easternmost part of Asia. Traditionally, the term has been used to refer to China, Hong Kong, Japan, Korea, Macao, Taiwan, and eastern Siberia in Russia. This region, excluding eastern Siberia, is now often called East Asia. The meaning of the term Far East is sometimes extended to also include Southeast Asia. The countries of Southeast Asia are Brunei, Burma, Cambodia, Indonesia, Laos, Malaysia, the Philippines, Singapore, Thailand, and Vietnam. Europeans created the term Far East. The region lies far to the east of Europe.

For more information on the Far East, see **Asia** (Way of life in East Asia; Way of life in Southeast Asia). See also the articles on the countries and other political units mentioned in this article.

Far West Home. See **Drummond, Stanley.**

Farad is a unit used to measure electrical capacitance. It is named after the English physicist Michael Faraday, and its symbol is F.

The electric charge in a capacitor is directly proportional to the *potential difference* (voltage) applied to it. If one coulomb of charge gives a capacitor a potential difference of one volt, the capacitance is one farad. In electronics, the *microfarad* and the *picofarad* are usually used to measure capacitance. A microfarad (μF) is one-millionth of a farad, and a picofarad (pF) is one-millionth of a microfarad.

See also **Capacitance; Capacitor; Coulomb; Volt.**

Faraday, Michael (1791-1867), one of the greatest English chemists and physicists, discovered the principle of electromagnetic induction in 1831 (see **Electromagnetism**). He found that moving a magnet through a coil of copper wire caused an electric current to flow in the wire. The electric generator and electric motor are based on this principle. Joseph Henry, an American

Michael Faraday was an English chemist and physicist. He discovered the principle of electromagnetic induction in 1831. The illustration above shows him working in his laboratory.

physicist, discovered induction shortly before Faraday, but failed to publish his findings (see **Henry, Joseph**).

Faraday's work in electrochemistry led him to discover a mathematical relationship between electricity and the *valency* (combining power) of a chemical element. Faraday's law states this relationship. It gave the first clue to the existence of electrons (see **Electron**). Faraday introduced ideas that would become the basis of field theory in physics. He maintained that magnetic, electrical, and gravitational forces are passed from one body to another through *lines of force,* or strains in the area between the two bodies.

Faraday was born near London. He was first apprenticed to a bookbinder. He became Sir Humphry Davy's assistant at the Royal Institution in London in 1813, and remained there for 54 years. Faraday was a popular lecturer. He gave scientific lectures for children every Christmas. The most famous of these lectures is "The Chemical History of a Candle."

See also **Electricity** (Electromagnetism).

Farce. See **Comedy** (with picture); **Drama** (Forms of drama [Comedy]; **Medieval drama** (Farces and interludes).

Fareham (pop. 97,300) is a local government district and market town in Hampshire, England. Fareham town stands on a creek at the northwestern end of Portsmouth harbour, about 8 kilometres across the water from Portsmouth. Fareham's port is used mainly by pleasure yachts. Boat building is an important industry in the town. Other industries in the district include fruit growing, dairy farming, brick making, meat processing, gravel quarrying, and light engineering. The district has some new industrial estates that are attracting new industries. See also **Hampshire.**

Fargo, William George (1818-1881), was a partner in the American gold rush express company of Wells, Fargo & Company (see **Wells, Fargo & Company**). His company's stagecoaches provided the best and fastest transportation between the East and the West of the United States in the mid-1800's. The city of Fargo, North Dakota, is named after him.

As a young man in Buffalo, New York, Fargo was a messenger with Wells and Company, the first express company to go west of Buffalo. Later, he became part owner.

Wells, Fargo operated in most parts of the country. When the transcontinental rail line was completed in 1869, the railway took most of the express business.

Fargo was born in Pompey, New York. He served as mayor of Buffalo from 1862 to 1866.

Farigoule, Louis. See **Romains, Jules.**

Farjeon, Eleanor (1881-1965), was a British author who became famous for her stories and poems for children. Her best-known works are noted for their combination of humour and fantasy.

Farjeon's collection *The Little Bookroom* (1955) contains her choices from among the many stories she wrote for children. The title refers to a small room where the author read as a child. Farjeon's other collections of stories include *Jim at the Corner and Other Stories* (1934) and *Martin Pippin in the Daisy-Field* (1937).

Farjeon selected a number of favourite poems from her works for the collection *The Children's Bells* (1934). The book includes poems on such subjects as fairies, the seasons, and the experiences of childhood. Many of her poems were also published in *Eleanor Farjeon's Poems for Children* (1951).

Farjeon was born in London. During her long writing career, she produced more than 100 books and plays, including a few for adults.

Farm and farming. See **Agriculture.**

Farm Cove is a bay on the southern side of Sydney Harbour, near Sydney Opera House, in New South Wales, Australia. It is the site of the Royal Botanical Gardens. The first farm animals were grazed and the first crops were grown there after Governor Phillip landed in 1788. Queen Elizabeth II stepped ashore there when she visited Australia for the first time on Feb. 3, 1954.

Farmer. See **Agriculture.**

Farnaby, Giles (1560?-1640), was an English composer. He is best known for his *canzonets* (songs), published in 1598, and for his music for *virginals* (small, simple harpsichords). His canzonets, more like madrigals in form, include "Blind Love Was Shooting" and "Construe my Meaning." This latter piece has unusually bold, dissonant harmonies. Musicians value Farnaby's virginal music, much of which is in the Fitzwilliam Virginal Book. Farnaby was probably born in London. He studied music at Oxford.

Farne Islands are a group of 25 to 30 small islands off the coast of Northumberland, northeastern England. They lie opposite the town of Bamburgh and southeast of Lindisfarne (Holy Island). The Farne Islands, which are virtually uninhabited, are owned by the National Trust. They are an important bird sanctuary and a breeding ground for seals. The island of Longstone has a lighthouse. St. Aidan visited the Farne Islands in A.D. 635. St. Cuthbert set up a hermitage on Inner Farne in 676.

Farnese Bull is a famous group sculpture that portrays an episode in Greek mythology. Its name comes from the Farnese Palace in Rome, where the sculpture was once kept. The *Farnese Bull* is a striking marble copy of a lost sculpture made in the 100's B.C. by the Greek sculptors Apollonios and Tauriskos of Tralles. Unknown Roman sculptors made the copy in the A.D. 200's. The copy was discovered during an excavation in Rome

Museo Archeologico Nazionale, Naples, Italy (Alinari, Art Resource, NY)

The *Farnese Bull* is a marble copy made in the A.D. 200's of an original Greek sculpture—now lost—carved in the 100's B.C.

in the 1500's, and lost portions of it were restored by Renaissance artists.

The sculpture shows two young men tying Dirce, the wife of King Lycus of Thebes, to a bull. Dirce had cruelly mistreated and imprisoned Antiope, who was Lycus' niece and, according to some stories, had been his first wife. Dirce planned to kill Antiope by binding her to a bull's horns. But Antiope's twin sons tied Dirce to the bull instead.

Farnsworth, Philo Taylor, (1906-1971), an American inventor, was a pioneer in television technology. While still a teenager, he created an electronic television system that was superior to the mechanical discs used experimentally at the time. At the age of 20, Farnsworth applied for a patent for an electronic television camera tube that became known as an *image dissector.* It created an image by producing an electronic signal that corresponded to the brightness of the objects being televised. Farnsworth demonstrated the image dissector in 1927. In 1939, the Radio Corporation of America (RCA) obtained a license from Farnsworth to produce electronic television transmission systems that combined his technology with theirs. Farnsworth later conducted research on radar and nuclear energy. He was born in Beaver, Utah, U.S.A.

Faroe Islands, also spelled *Faeroe* and *Føroyar,* are a group of 18 islands and some reefs in the North Atlantic Ocean. They lie between Iceland and the Shetland Islands. The group has an area of 1,400 square kilometres, and a population of about 42,000. Major islands are Streymoy, Eysturoy, Vágar, Sudhuroy, and Sandoy.

The 225-kilometre coastline is steep and deeply indented. Treacherous currents along the shores of the islands make navigation difficult. The islanders are of Norse origin. They fish and raise sheep. They also sell the eggs and feathers of the sea birds that nest on the cliffs. They do little farming.

Location of Faroe Islands

Norway ruled over the Faroe Islands from the 800's until 1380, when the islands came under the control of Denmark. British forces occupied the islands during World War II, but the civil government remained the same. In 1948, Denmark granted the Faroes self-government. The islanders have their own parliament, or *Lagting,* and send representatives to the Danish parliament in Copenhagen. The seat of government is Tórshavn on Streymoy.

See also **Europe** (picture: Special political units).

Farouk I. See Faruk I.

Farquhar, George (1678-1707), is a transitional figure in the history of English drama. His plays contain the wit found in Restoration comedy of the late 1600's and the emphasis on character and plot found in English plays of the 1700's.

Farquhar wrote eight comedies during his brief life, and is best known for two of them. In *The Beaux' Stratagem* (1707), two young Londoners visit a country town, seeking rich wives in order to regain their wasted fortunes. Both have comic adventures, and one wins an heiress. *The Recruiting Officer* (1706) describes the adventures of army recruiters in an English country town.

Farquhar was born in Londonderry, Ireland, and worked briefly as an actor in Dublin, before going to London to write comedy. A careless young man, he lived in constant need.

Farrar, Frederic William (1831-1903), an English clergyman and schoolmaster, is best remembered as the author of *Eric, or Little by Little* (1858), an edifying story of a boy's school life. He also wrote a number of theological works that were popular in Victorian times. These works include *The Life of Christ* (1874) and *The Life and Works of St. Paul* (1879). *Eternal Hope* (1877), a collection of sermons in which he questioned the doctrine of eternal punishment for sinners, caused some controversy. Farrar was born in Bombay, India. He became headmaster of Marlborough College, a private school in Marlborough, Wiltshire, England, in 1871 and Dean of Canterbury Cathedral in 1895.

Farrell, James T. (1904-1979), was an American writer best known for his novels about lower middle-class life in a decaying neighbourhood of a large city. Farrell followed the theory of naturalism in his early works, believing that people are influenced overwhelmingly by their environment (see **Naturalism**). Farrell's best-known work is the *Studs Lonigan* trilogy—*Young Lonigan* (1932), *The Young Manhood of Studs Lonigan* (1934), and *Judgment Day* (1935). These novels are written largely in the language of Lonigan, a streetwise young man. They explore the impact of urban industrial life on a boy growing up in a poor Chicago neighbourhood. James Thomas Farrell was born and raised in Chicago. After attending the University of Chicago, he became a writer.

Farrer, William (1845-1906), became known as the *father of the Australian wheat industry* because of his pioneering work in breeding new varieties of wheat.

William James Farrer was born in the village of Docker, in Westmorland, England, where his father was a tenant farmer. He won a scholarship to Cambridge University, where he took a degree in mathematics. He wanted to become a doctor but abandoned this goal when he discovered he had tuberculosis. In 1870, he sailed for Australia, hoping that a better climate would help ease his condition.

Farrer worked as a country surveyor until he had saved enough money to buy a farm. In 1886, he bought a sheep farm called *Lambrigg,* near present-day Canberra. There, he experimented in breeding different varieties of wheat that would suit the Australian climate. He called his most famous variety *Federation* to mark the foundation of the Australian Commonwealth in 1901. The wheat proved extremely popular with Australian farmers and was also adopted in India, and in California, in the United States. It was not until the 1920's that a better wheat was bred to replace it. Farrer's high-yielding wheat greatly increased Australian farmers' incomes.

In 1898, Farrer was appointed as wheat experimentalist in the New South Wales Department of Agriculture. He was paid 700 Australian dollars a year. In those days, this was a good salary, and Farrer was considered well off. But Farrer was not greatly interested in money. He enjoyed his work. What did upset him was the political opposition and criticism he received from ill-informed people within the public service. By the time of his early death, probably brought on by overwork, he was an internationally famous scientist.

See also **Federation wheat.**

Farrier. See **Blacksmith.**

Farsightedness. See **Longsightedness.**

Farthing was a coin of the lowest value in British currency. It was worth one-fourth of an old penny, or the 960th part of a pound sterling (see **Pound**). The farthing was first issued in 1279, as a silver coin. In 1613, bronze replaced silver as the metal used in the *minting* (making) of the farthing. The British government withdrew the farthing from circulation on Jan. 1, 1961. The word *farthing* is sometimes used to mean a measure of land.

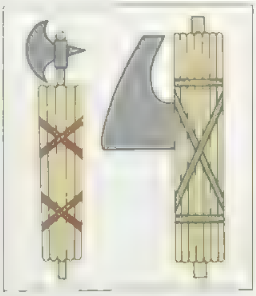
The farthing was a British coin. One side showed the British monarch. The other side pictured a perching wren. The photograph has been enlarged to show the details.

Farthingale. See **Clothing** (The Renaissance).

Faruk I (1920-1965), also spelled *Farouk,* was the last king of Egypt. He became king in 1936, succeeding his father, Fuad I. Faruk enjoyed great popularity at first. But he shirked his duties and followed a life of luxury and dissipation. A rebel group, directed by General Muhammad Naguib, forced Faruk to abdicate in July 1952. They charged there was corruption in the government. Faruk went into exile in Europe. He was born in Cairo, and died in Rome.

See also **Egypt** (History); **Nasser, Gamal Abdel.**

Fasces were a symbol of power in the days of the Roman Republic, of the Roman Empire, and, later, of Benito Mussolini's Fascist government in Italy. Fasces consisted of a bundle of birch or elm rods bound together by a red strap. The blade of an axe projected from the bundle. Servants called *lictors* carried these bundles ahead of such officials as magistrates, governors, and emperors. The fasces stood for the official's power to punish or put to death, and also symbolized unity. Fasces also appear on the back of some U.S. dimes (10 cent coins).



Fasces

Fascism is a form of government headed, in most cases, by a dictator. It involves total government control of political, economic, cultural, religious, and social activities.

Fascism resembles Communism. But unlike Communism, which calls for the government to own all industry, fascism allows industry to remain in private ownership, though under government control. Other important features of fascism include extreme patriotism, warlike policies, and persecution of minorities.

The word *fascism* also describes any governmental system or political belief that resembles those of Benito Mussolini and Adolf Hitler. Fascist governments ruled Italy under Mussolini from 1922 to 1943, and Germany under Hitler from 1933 to 1945.

Fascism has varied from country to country. This article discusses fascism mainly as it existed in Italy under Mussolini and in Germany under Hitler.

Life under fascism

Political life. In most cases, fascists have come to power after a country has suffered an economic collapse, a military defeat, or some other disaster. The fascist party wins mass support by promising to revive the economy and to restore national pride. The fascists may also appeal to a fear of Communism or a hatred of Jews and other minorities. Eventually, the fascists may gain control of the government—through peaceful elections or by force.

After the fascist party takes power, its members replace the men and women in the executive, judicial, and legislative branches of the government. In most cases, one individual—usually a dictator with great popular appeal—becomes the leader of the government. Sometimes, a committee of party members holds the government leadership. Fascists permit no other political party and no opposition to their policies.

Adolf Hitler was leader of a fascist party in Germany known as the Nazi Party. He was called der Führer.

The fascist desire for national glory leads to an increase in military spirit and a build-up of the armed forces. After the military forces become strong enough, they may invade and occupy other countries.

Economic life. A fascist government permits and even encourages private enterprise—as long as such activity serves the government's goals. However, the government maintains strict control of industry to make sure it produces what the country needs. The government discourages imports by putting high tariffs on certain essential products or by banning imports of those products. It does not want to depend on other countries for such vital products as oil and steel.

The government also forbids strikes, so that production will not be interrupted. Fascism outlaws labour unions and replaces them with a network of organizations in the major industries. These organizations, which consist of both workers and employers, are called *corporations,* but they differ from those in other countries. Fascist corporations supposedly represent both labour and management. In reality, these corporations are controlled by the government. Through the corporations, the government determines wages, hours, and production goals. As a result, a fascist country is sometimes called a *corporative state.*

Personal liberty is severely limited under a fascist government. For example, the government limits travel to other countries and restricts any contact with their people. The government also controls the newspapers, radio, and other means of communication in its country. It issues propaganda to promote its policies, and it practises strict censorship to silence opposing views. All children are required to join youth organizations, where they exercise, march, and learn fascist beliefs. A secret police force crushes any resistance. Opposition may lead to imprisonment, torture, and death.

Fascists consider all other peoples inferior to those of their own nationality group. As a result, a fascist government may persecute or even kill Gypsies, Jews, or members of other minority groups.

History

The word *fascism* comes from ancient Roman symbols of authority called *fasces* (see **Fasces**). Benito Mussolini originated the term in 1919, but fascism itself is much older than its name.

Many historians trace the beginning of modern fascism to Napoleon I, who ruled France as a dictator during the early 1800's. Napoleon carried out many liberal reforms and was not a true fascist. But fascists later adopted many of his methods. Napoleon promised his people that he would restore the glory of France through military conquest. To prevent opposition, he established one of the first secret police systems. Napoleon also used propaganda and strict press censorship to win support of his programmes.

Fascism in Italy. Italy was on the winning side when World War I ended in 1918, but the war left the country in a poor economic condition. In addition, the peace treaties gave Italy far less territory than it had expected to receive. Benito Mussolini's Fascist Party promised to give Italians prosperity and to restore the prestige Italy had held during the days of the Roman Empire. The party gained the support of many landowners, business and military leaders, and members of the middle class. By 1922, the Fascists were powerful enough to force the king of Italy to make Mussolini prime minister. Mussolini, who became known as *Il Duce* (the leader), soon began to create a dictatorship. He banned all political parties except the Fascist Party and seized control of the country's industries, newspapers, police, and schools.

In 1940, Mussolini led Italy into World War II on the side of Nazi Germany. The Fascist government was overthrown in 1943, when Italy surrendered to the Allies.

Fascism in Germany. Germany was defeated in World War I and lost much of its territory under the peace treaties. The treaties also forced Germany to disarm and to pay heavy penalties for war damages. Severe inflation during the 1920's and a worldwide depression in the early 1930's left the German economy in ruins.

A fascist party called the National Socialist German Workers' Party, or Nazi Party, gained strength rapidly during the postwar period of crisis. By 1933, the Nazis were the strongest party in the country. Their leader, Adolf Hitler, became the head of the government that year. Hitler soon overthrew the constitution and began to make Germany a fascist state. His secret police wiped out any opposition.

Hitler, who was called *der Führer* (the leader), preached that Germans were superior people and that Jews, Slavs, Gypsies, and other minorities were inferior. His followers used these beliefs to justify the brutal Nazi persecution of Jews and other groups. The Nazis eventually killed about 6 million Jews.

Hitler vowed to extend Germany's borders and to avenge the country's humiliation in World War I. He began to build up the armed forces and prepare for war. In 1939, World War II began when German armies invaded Poland. The Allies defeated Germany in 1945, and the Nazi government crumbled.

Fascism in other countries. In Hungary, a fascist party called the Arrow Cross gained much support in the late 1930's. During the same period, a fascist organization called the Iron Guard became the strongest political party in Romania. Fascist groups also gained considerable strength in Japan during the 1930's. All these fascist movements disappeared after the Nazi defeat in 1945.

In Argentina, Juan D. Perón established a fascist dictatorship in 1946 and ruled until 1955, when a revolt forced him to resign. His supporters remained active, however, and Perón returned to power in 1973, during a period of economic difficulty in Argentina. He ruled until his death the next year.

During the Spanish Civil War (1936-1939), a fascist group that was called the Falange Española supported the revolutionary forces that were led by Francisco Franco. Franco's forces won the war, and he ruled Spain as a dictator from 1939 until his death in 1975. Many people consider the Franco government to have been fascist. However, most historians and political scholars believe that the Franco government lacked essential features of fascism.

Today, the rulers of many developing countries are following fascist policies in an effort to promote industrial growth and national unity. But because of the association of fascism with racism—and with Mussolini and Hitler—these leaders deny any similarity to fascist dictators.

Related articles in ***World Book*** include:

Black Shirt
Fasces
Germany (Nazi Germany)
Hitler, Adolf
Italy (Italy under Mussolini)
Mussolini, Benito
Nationalism
Nazism
Police state
Romania (Depression and fascism)
Totalitarianism
World War II (The rise of dictatorships)

Fashion is a term commonly used to describe a style of clothing worn by most of the people of a country. However, popular styles of cars, furniture, homes, and many other products are also fashions. The kinds of art, music, literature, and sports that many people prefer can likewise be called fashions. Thus, a fashion is—or reflects—a form of behaviour accepted by most people in a society.

A fashion remains popular for a few months or years before being replaced by yet another fashion. A product or activity is *in fashion* or is *fashionable* during the period of time that a large segment of society accepts it. After a time, however, the same product or activity becomes *old-fashioned* when the majority of people no longer accept it.

Most people do not easily accept extreme changes in fashion. Therefore, most new fashions closely resemble those they replace.

A clothing style may be introduced as a fashion, but its use becomes a *custom* if it is handed down from generation to generation. For example, in the early 1800's, long trousers replaced knee-length pants and stockings as the fashion in men's clothing in Europe and the United States. Today, wearing long trousers is a custom for men in most countries. But fashionable variations in the colour and shape of trousers have occurred over the years.

A fashion that quickly comes and goes is frequently called a *fad*. The majority of people do not accept fads. Some people may become involved in faddish behaviour because fads can be widely publicized. Fads of the mid-1900's included playing with such toys as hula hoops and skateboards.

Why people follow fashion

Before the 1800's, some countries had laws that regulated the clothing fashions of people in certain social classes. Many of these *sumptuary laws* were designed to preserve the class system. Sometimes, they forced people to buy products manufactured in their own country. An English law of the 1600's required men of the lower classes to wear woollen caps made in England. However, this same law permitted men of high position to wear velvet hats from France and Italy.

Today, people follow fashion for various reasons. For example, they may want to identify with a select group of people. New fashions may be adopted immediately by well-known people, including athletes, film stars, and political figures. Then, other people may follow these fashions so that they can identify with this privileged group. Some people think that fashionable clothes and surroundings raise their status in life.

Following fashion provides a way for people to gain acceptance from others. This adoption of fashion applies more to clothes and social behaviour than to cars, houses, and other items that most people cannot afford to replace frequently. During the 1950's and 1960's, many young people identified with one another's political and social beliefs by wearing blue jeans. After a while, blue jeans became a fashion that was accepted by a wide variety of people.

People also follow fashion to make themselves more attractive. Standards of beauty change over the years, and people decorate themselves to fit their society's changing standards. Ideas of beauty also vary from culture to culture. For example, people in many countries use cosmetics to increase their attractiveness. In some countries, people use tinted cream on their cheeks. In other countries, people decorate themselves with tattoos and with scars filled with coloured clay.

Men and women have always enjoyed changing their appearance. Following new fashions in clothes, hair styles, and makeup allows people to alter their appearance in a generally accepted way.

What causes fashion to change

Major changes in fashion occurred infrequently before the 1300's. Since then, the political and social conditions of a country, plus technological developments, have influenced fashion in various ways.

Political and social conditions. During the 1300's, the rulers of many European countries began to set fashions that were followed by the members of their courts. In the mid-1600's, King Louis XIII of France began wearing a wig to hide his baldness. Fashionable Frenchmen soon began to shave their heads and wear wigs. In the mid-1800's, English women are said to have copied Queen Victoria's stout figure by wearing puffy dresses with padding underneath.

Some fashion changes have accompanied a breakdown in the system of social classes. The members of the nobility lost much of their power during the 1300's,

Fashions in clothing, furniture, and interior decoration change over the years. The decorative styles of the 1890's, *left*, gradually gave way to the simpler fashions of the 1940's, *right.*

when rigid class systems were weakened in Europe. The nobility began to dress more elaborately to distinguish themselves from the middle classes.

During the mid-1800's, mass production of clothing made fashionable clothes available to more people at lower prices. People of all social classes began to wear similar styles of clothing. Today, it is easier to identify an expensive garment by the quality of its fabric and manufacture than by its style.

Over the years, fashions in games and sports have influenced the way people dress. During the 1700's, people in England adopted simpler clothing styles after they became interested in fox hunting and other outdoor sports. Today, many people wear special clothing for such activities as golf, horse riding, hunting, and tennis.

Wars have also affected the style of dress in a country. European soldiers returning from the crusades during the 1100's and 1200's brought back various Eastern ideas of dress styles. The crusaders also returned with rich silk and other textiles that were not available in Europe.

During the French Revolution (1789-1795), the elegant dress styles associated with the French nobility were replaced by plainer fashions. After Napoleon became emperor in 1804, he brought back elaborate fashions in clothing for the court.

During World War II (1939-1945), the shortage of fabrics limited new fashions. The governments of many countries restricted the amount of fabric that could be used in various garments. Nylon stockings were also scarce during World War II, and many women began wearing leg paint.

Technological developments. The development of new dyes, machinery, and textiles has greatly affected most areas of fashion, especially clothing. The style of dress has changed frequently in countries that have highly mechanized production systems.

During the early 1700's, new dyes made new colour combinations possible in clothes. In the late 1700's, the invention of the toothed cotton gin, the power loom, and other machines sped up the production of fabric and yarn. Industrial mass production of clothing began after the development of improved sewing machines during the mid-1800's. The production of many identical garments resulted in a more uniform clothing style for many people. Since that time, the garment industry has influenced the design of new clothing fashions.

In the early 1900's, manufacturers began to make clothing and other products from synthetic fabrics. These materials have become popular because they are easier to care for and less expensive than some natural fibres. People began to wear lighter-weight clothing at about the same time, following the development of more efficient heating systems.

At one time, changes in fashion spread slowly from one country to another. Today, various communication systems keep people informed on current fashion developments in all parts of the world.

Related articles in *World Book* include:

Brummell, George B.	Hat
Clothing	Shoe
Hairdressing	

Fast is abstinence from food, or certain kinds of food, for a period of time. The origin of *fasting* is unknown. But the custom of fasting has played a part in the practices of every major religious group at some time.

There are many purposes for fasting. It has often been a way in which people have sought pardon for their misdeeds. In some religions, people fast during times of mourning. In others, people believe that fasting will take their minds off physical things, and produce a state of spiritual joy and happiness.

There are important fast days in Judaism, Christianity, and Islam. Jewish law orders a yearly fast on *Yom Kippur,* the Day of Atonement. Many orthodox Jews follow the custom of having the bride and groom fast on the

day before their wedding. Many Christians fast during Lent, the period of 40 days from Ash Wednesday until Easter, commemorating the 40 days that Jesus spent fasting in the wilderness. In general, for Christians, fasting seldom means doing without all food for an entire day at a time. In addition, people who are not well can usually receive permission from their religious leaders not to fast.

Muslims fast from dawn to dusk every day during Ramadan, the ninth month of their year. During these hours, they abstain from food and beverage, even though this month often comes during the hottest season of the year. Buddhists and Hindus also fast.

Many people have fasted at some time during their lives, for religious reasons, for initiation ceremonies, or for help in developing magical powers or control over the body. In some religions, such as Zoroastrianism, religious leaders have protested against fasting from food. They claim that the food fast actually has no moral value, when compared with "fasting from evil" with eyes, hands, tongue, or feet.

Sometimes, personal or political goals are sought through fasting. Mohandas Gandhi of India used fasting both as a penance and as a means of political protest (see **Gandhi, Mohandas Karamchand**).

People have also fasted for health reasons. Scientists have studied the effects of fasting on the body and found that the intake of food increases the body's metabolism (see **Metabolism**). After fasting, metabolism can become as much as 22 per cent lower than the normal rate. But research has also shown that, after long periods of fasting, the body tends to adjust itself by lowering the rate of metabolism itself. After fasting, a person should gradually resume eating. Religious groups do not intend fasting to be harmful. They believe that it promotes self-control and strengthens the will.

Fat is any of a group of chemical compounds found in both animals and plants. Fats are composed of carbon, hydrogen, and oxygen. They are one of the three main classes of food essential to the body. The others are carbohydrates and proteins.

An animal fat or plant fat that is liquid at room temperature is called an *oil.* Fats and oils are insoluble in water, but they can be dissolved in alcohols, chloroform, ether, and petrol. Beef tallow and some other fats are hard at room temperature. Such fats as butter, lard, and margarine, are soft at room temperature.

Fat has many important uses. It is a concentrated source of food energy for animals and plants. Fat is stored under the surface of the skin of most kinds of animals, including human beings. These fat deposits act as insulation against heat loss. Deposits of fat around the eyeballs and other organs of animals serve as cushions against injury. In plants, most fat is stored in the seeds. Many industries use both animal and plant fats in the manufacture of various products.

Nutritional importance. Fat is an important energy source in the diet and is a more efficient fuel than either carbohydrates or proteins. Fat can produce about 9 calories of energy per gram. Carbohydrates and proteins can each produce about 4 calories per gram, or less than half the energy produced by fat.

Because of its high energy content, fat is the body's most efficient form of stored fuel. The body can store fat that is almost dry, but large amounts of water are necessary to store carbohydrates and proteins. The body converts carbohydrates and proteins into *adipose* (fatty) tissue for storage. When extra fuel is needed, the body draws on this stored fat.

Fats are composed of substances called *fatty acids* and an alcohol called *glycerol.* Certain fatty acids, known as *essential fatty acids,* are necessary for the growth and maintenance of the body. The body cannot manufacture essential fatty acids, and so they must be included in the diet.

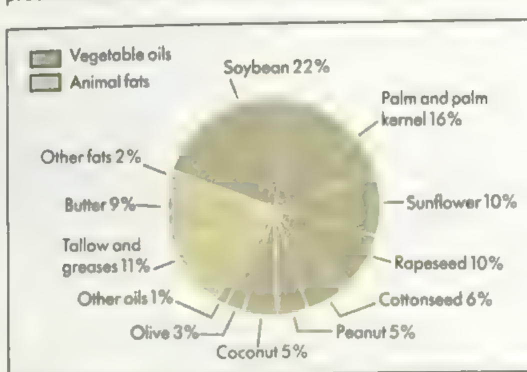
Essential fatty acids are building blocks for the membranes that make up the outer border of every cell in the body. They also form many of the complicated structures inside body cells. Essential fatty acids are a main part of the membranes of the *retina,* the part of the eye that turns light into nerve impulses. *Synapses,* the junctions between the body's individual nerve cells, are also rich in essential fatty acids.

Dietary fats can be divided into two general groups, *visible fats* and *invisible fats.* Most people are aware of the visible fats they eat, such as the fat in meat, butter, and salad oils. But some individuals may not be aware of the invisible fats in such foods as milk, eggs, fish, and nuts. Invisible fats are spread finely throughout certain animals and plants. Many such fats are especially rich in essential fatty acids.

Fats and disease. Many scientists believe that controlling the consumption of fats can help reduce the risk of developing *coronary heart disease.* This disease results when deposits of *cholesterol,* a white waxy substance, buildup on the inner walls of the arteries that nourish the heart. The artery walls may eventually become hard, rough, and narrow. Many heart attacks result from a blood clot that blocks a narrowed coronary artery.

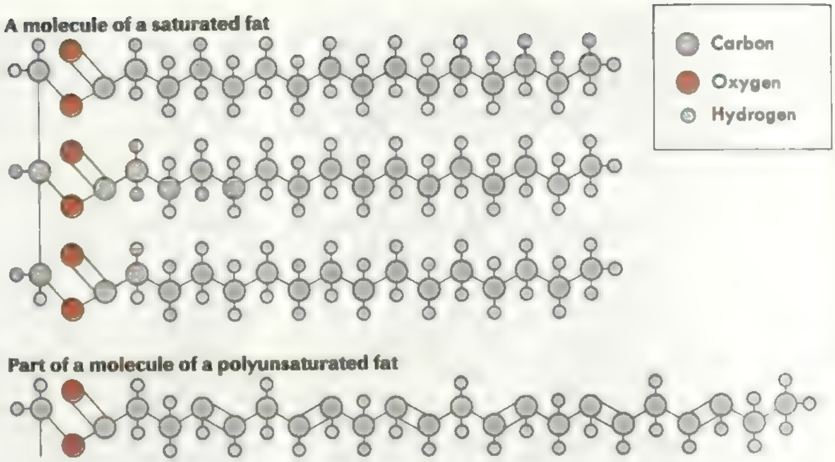
Certain kinds of fats, called *saturated fats,* seem to increase the amount of cholesterol in the blood. Many scientists recommend limiting the intake of foods high in cholesterol and saturated fats. Instead, they recommend diets high in *unsaturated fats* and *polyunsaturated fats,* which seem to lower the cholesterol in the blood. In 1984, researchers reported evidence that lowering high

Sources of fats and oils
Vegetable oils account for about three-fourths of the world's production of fats and oils. Animal fats make up the remainder.



Source: *Foreign Agriculture Circular: Oilseeds and Products,* U.S. Department of Agriculture, August 1986

The structure of fats
A molecule of fat includes three fatty acid chains, each of which consists of a chain of carbon atoms with hydrogen atoms attached. The structural diagram at the top of this illustration shows one molecule of a *saturated fat.* The fatty acid chains are saturated with hydrogen—that is, each carbon atom is linked to as many hydrogen atoms as possible. The bottom diagram shows one of the three chains of a *polyunsaturated fat.* Several of the carbon atoms in this chain are linked to only one hydrogen atom.



blood levels of cholesterol reduces heart disease. But many scientists agree that other factors—such as smoking, stress, lack of exercise, or being overweight—contribute at least as much as diet to the development of coronary heart disease. See **Cholesterol.**

An excessive accumulation of fat in adipose tissue is called *obesity.* Obesity can be caused by too much food, too little exercise, or glandular disorders. Some diseases, such as appendicitis, cirrhosis of the liver, coronary heart disease, and diabetes, can be more difficult to treat if the patient is obese.

Structure. Most fats consist of one molecule of glycerol, also called *glycerin,* combined with three molecules of fatty acids. Each of these fatty acids is a long chain of carbon atoms with hydrogen atoms attached to them. The fatty acid chains are linked to the glycerol molecule to form a molecule of fat.

A saturated fatty acid has as many hydrogen atoms as possible attached to its carbon chain. The carbon atoms of the chain are linked together by single bonds. *Stearic acid* is an example of a saturated fatty acid.

In an unsaturated fatty acid, at least one pair of carbon atoms is joined by a double bond. For each such bond, the carbon chain is missing a pair of hydrogen atoms. *Oleic acid* is an example of an unsaturated fatty acid.

A fatty acid that has more than one double bond is called polyunsaturated. The most highly polyunsaturated fatty acid in the body is known as *22:6.* It has a chain of 22 carbon atoms and 6 double bonds.

The hardness of a fat decreases as the number of double bonds in its fatty acid chains increases. The length of the carbon chain in the fatty acid also influences the hardness of a fat. Hard fats are less unsaturated than soft fats. Most liquid fats, such as vegetable oils and fish oils, are polyunsaturated.

A fat can be hardened by artificially adding hydrogen to the double bonds of the fatty acid, making the fatty acid less unsaturated. This process is called *hydrogenation* (see **Hydrogenation**).

Industrial uses. Fats from a wide variety of plants and animals supply many of the raw materials used in manufacturing. The hydrogenation of various vegetable oils, such as corn, cottonseed, and soybean oils, produces margarines and shortenings. Linseed oil is used in making paints that have an oil base. Manufacturers use coconut oil in making hydraulic-brake fluid, lipstick, soap, and chocolate coating for sweets and ice creams. Beef fat, called *tallow,* is an important ingredient in soaps, cosmetics, and lubricants.

Related articles in *World Book* include:

Blubber	Oil
Butter	Perfume
Detergent and soap	Stearic acid
Glycerol	Suet
Lard	Tallow
Margarine	Vegetable oil
Nutrition (Fats)	

Fat hen is a tall weed related to beets and spinach. It grows in fields and gardens and along roads in the Northern Hemisphere. The plants range in size from about 30 centimetres to 3 metres. Clusters of tiny greenish flowers hang from the stem. The young shoots are whitish. The leaves are lance or diamond shaped, and the lower ones are toothed. Fat hen is a nuisance to farmers because its seeds become mixed with grain seeds. The tasty leaves are sometimes cooked and eaten as greens.

Scientific classification. Fat hen belongs to the goosefoot family, Chenopodiaceae. It is *Chenopodium album.*

Fatalism is the belief that events are determined by forces that human beings cannot control. Although all fatalists accept this general belief, they hold different views about the kinds of forces that determine events. In Greek mythology, for example, three goddesses called the Fates controlled human destiny. Theological fatalists believe that God determines what will happen. Scientific fatalists, generally called *determinists,* believe events are caused by physical, chemical, and biological forces described in scientific theories.

Fatalists may also hold differing views about whether all events are predetermined as part of a universal plan or order, or whether only some events are destined to occur. Those who base their fatalism on science generally hold the universal form of fatalism. Because fatalists believe some or all future events are as unchangeable as past events, they often believe it is possible to predict the future.

See also **Predestination; Free will; Fates.**

Fates were three goddesses who ruled people's lives. According to Greek and Roman mythology, the goddesses spun and cut the thread of life. They were called *Parcae* among the Romans and *Moirai* among the Greeks. Clotho was the spinner of the thread and Lachesis decided how long it was to be. Atropos cut the thread.

The Fates were stern and gloomy goddesses. Nothing could make them change their minds. People offered them gifts to escape death, but never to thank them for any kind of blessings.

Ancient artists represented Clotho as holding the spindle of thread. Lachesis carries rods which she shakes to decide a person's fate. Atropos holds a tablet on which she writes the decision.

See also Norns.

Father of medicine. See **Hippocrates.**

Father's Day is a day on which the people of many countries express gratitude and appreciation for their fathers by giving them gifts or greetings cards. In the United Kingdom, the United States, and Canada, Father's Day falls on the third Sunday in June. In Australia, it is normally celebrated on the first Sunday in September.

Sonora Louise Smart Dodd of Spokane, Washington, U.S.A., got the idea to set aside a special day to honour fathers in 1909, after listening to a sermon on Mother's Day. She wanted to honour her father, William Jackson Smart. Smart's wife had died in 1898, and he had raised their six children on his own. Dodd drew up a petition recommending adoption of a national father's day. The Spokane Ministerial Association and the local Young Men's Christian Association (YMCA) supported it. Through Sonora Dodd's efforts, Spokane celebrated the first Father's Day on June 19, 1910. The custom later spread to other countries.

Fathom is a unit of length used to measure ropes or cables and the depth of water. One fathom is equal 1.8 metres. Navigators mark a rope in fathoms and drop it into the water in order to measure the depth. Sailors of average height often measured fathoms roughly by extending both arms and measuring the rope from finger tip to finger tip.

Fathometer is an instrument used on ships to measure the depth of water. It works by sending a sound down through the water to be echoed back up from the bottom. Navigators can measure the depth below the ship by measuring the time it takes the sound to return, as the speed of sound in water is known. Continuous soundings of this kind can be taken throughout a voyage.

The fathometer contains two parts, a *submarine oscillator,* which produces the sound, and a hydrophone *echo receiver.* The echo is amplified and sent to a *depth indicator* and a *recorder* near the bridge of the ship. The reliability of a fathometer depends on a number of factors, including the depth, temperature, and saltiness of the water.

See also **Sonar.**

Fatigue is another name for tiredness. People often say they are "fatigued" when they feel tired. If we work hard, play hard, or go without rest or sleep, we expect to feel fatigued. In such cases, fatigue is normal. We know from experience that this feeling will disappear after we rest. But sometimes fatigue is a symptom of illness. Physically ill people often become fatigued after even a slight amount of work or exertion. Such people need a great deal of rest, often much more than they would need if they were well. Doctors have found that fatigue occurs frequently during many kinds of illness.

Fatigue may be one of the symptoms of a physical illness. It may also be a symptom of *depression* (see **Mental illness** [Affective disorders; Anxiety disorders]). In either case, rest helps a person feel less tired. But no amount of rest will cure the tendency to become tired easily. This tendency will disappear or improve only if the physical or mental illness that causes the fatigue is improved or cured.

Doctors do not know exactly what causes fatigue. They do not know why a person feels tired after exertion or mental effort. However, they do know that psychological as well as physical factors contribute to fatigue. The effect of fatigue has been closely studied. Research workers have shown that people who spend long hours at things that bore them or at tasks they do not want to do soon develop fatigue. If the person's *morale* (general attitude) and *incentive* (promise of reward) are good, it takes longer for fatigue to develop. But, no matter how good morale or incentive might be, a person who works or plays long enough or hard enough will develop a feeling of fatigue.

See also **Health.**

Fatigue, Metal. See **Metal fatigue.**

A fathometer is a marine instrument that sends sound pulses from a vessel to the sea floor to determine the water's depth. Depth measurements are traced on a recorder aboard ship.

Fatima (605?-633), was the daughter of the Prophet Muhammad and the wife of Ali. Fatima's husband was the fourth *caliph* (successor to Muhammad as leader of the Muslims) and the central figure in the development of Shiite Islam (see **Ali ibn Abi Talib**).

Fatima was born in Mecca, in Saudi Arabia. As a teenager, she accompanied Muhammad to Medina in 622. After her marriage to Ali, son of one of her father's uncles, Fatima lived in poverty and endured harshness at the hands of her husband until the Prophet reconciled them. She nursed her father in his last illness and died shortly after him, having disputed her inheritance with Abu Bakr, the Prophet's successor. The Fatimid dynasty (909-1171), which founded Cairo, and ruled much of northern Africa and the eastern Mediterranean, claimed descent from her.

Fátima (pop. 3,464), is a town in west-central Portugal and the site of a famous religious shrine. For location, see **Portugal** (political map). The Virgin Mary, also called Our Lady of Fátima, reportedly appeared near Fátima in 1917. On May 13 of that year, three children told of seeing a vision of a lady near Fátima while they were tending sheep. They said that the lady, dressed in a white gown and veil, told them to come back there on the 13th day of each month until the following October when she would tell them who she was. On October 13, she said that she was Our Lady of the Rosary, and told the children to recite the rosary every day. She called for people to reform their lives and asked that a chapel be built in her honour. In 1930, the Roman Catholic Church authorized devotion to Our Lady of Fátima. Since then, millions of people have made pilgrimages to Fátima.

Fátima, in Portugal, is the site of a famous religious shrine. The basilica stands at the Shrine of Our Lady of Fátima.

Fatimah, Hajjah (? - ?), a Malay woman, built the Hajjah Fatimah Mosque in Singapore between 1845 and 1846. The mosque was made a national monument in 1973. Hajjah Fatimah was born in Malacca, in what is now Malaysia. She moved to Singapore, where she established a successful trading business. She married a prince from Sulawesi, in Indonesia.

Fatimah Hashim (1924-) was a leader of the women's section of the United Malays National Organization (UMNO), the main political party of Malaysia. In 1969, she was appointed to the welfare ministry and became Malaysia's first woman minister. She held the post until 1973. During this time, she worked to raise political awareness among Malaysian women, and to improve their welfare. Later, she devoted most of her time to helping women's groups, including the National Council of Women's Organizations.

Fatimah Hashim was born in Johor and attended various religious schools. Her participation in Malaysian politics, with her husband, Kadir Yusof, greatly contributed to the development of the country after it became independent in 1957.

Fatimid dynasty was a line of Muslim *caliphs* (rulers) who held power from A.D. 909 to 1171. The caliphs claimed descent from Fatima, the daughter of the Prophet Muhammad, and her husband, Ali, a cousin of the Prophet. The Fatimids belonged to the Shiite branch of Islam, and to a sect called the Seveners. In 909, they gained control over territory that had been held by the larger group of rival Sunni Muslims and rose to power in north Africa. At various times, their empire included Sicily, Syria, and parts of Arabia and Palestine.

For many years, the Fatimids made their capitals in what are now the cities of Al Qayrawan and Al Mahdiyah, Tunisia. But after winning control of Egypt in 969, they founded a new capital, Cairo. There, they built many beautiful buildings and established Al-Azhar University. Today, this university is one of the oldest universities in the world and the most influential religious school in Islam. The Fatimids also established great libraries in Cairo and in Tripoli, Lebanon.

The Fatimid caliphs were good leaders, but as time went on, they became lazy and lost their authority. Members of the court struggled for power in the 1160's, and Nur al-Din, a Syrian leader, became involved. The last Cairo caliph asked Nur al-Din for protection against an invasion in 1168. Nur al-Din sent a strong force that included Saladin, a soldier who overthrew the Fatimid dynasty in 1171.

See also **Muhammad; Saladin; Shiites; Cairo** (History).

Faulkner, Brian (1921-1977), was prime minister of Northern Ireland from 1971 until the position was suspended in March 1972. Until the end of 1973, the United Kingdom government ruled Northern Ireland directly from London. For a few months in 1974, Faulkner was chief minister of the Northern Ireland executive. This executive collapsed after a strike by Protestants who opposed it, and direct rule resumed. Faulkner became a life peer in January 1977.

Arthur Brian Deane Faulkner was educated at St. Columba's College, Dublin, Ireland. From 1941 until 1963, he was a director of his family's firm of shirt and collar manufacturers. In 1949, he became a member of the Stormont (Northern Ireland) Parliament. Faulkner served as government chief whip and parliamentary secretary to the Ministry of Finance from 1956 to 1959. In 1959, he became minister of home affairs. From 1963 to 1969, as minister of commerce, Faulkner attracted many new industries to Northern Ireland. From 1969 until 1971, he was minister of development.

Faulkner, William (1897-1962), ranks among the leading authors in American literature. He gained fame for his novels about the fictional "Yoknapatawpha County" and its county seat of Jefferson. Faulkner patterned the county after the area around his hometown, Oxford, Mississippi, in the Southern United States. He explored the county's geography, history, economy, and social and moral life. Faulkner received the 1949 Nobel Prize for literature. He won Pulitzer Prizes in 1955 for *A Fable* and in 1963 for *The Reivers.*

Faulkner's work is characterized by a remarkable range of technique, theme, and tone. In *The Sound and the Fury* (1929) and *As I Lay Dying* (1930), he used a stream-of-consciousness technique, in which the story is told through the seemingly chaotic thoughts of a character. In *Requiem for a Nun* (1951), Faulkner alternated sections of prose fiction with sections of a play. In *A Fable* (1954), he created a World War I soldier whose experiences parallel the Passion of Jesus Christ. Faulkner skilfully created complicated situations that involve a variety of characters, each with a different reaction to the situation, sometimes expressed as an interior monologue. He used this technique to dramatize the complexity of life and the difficulty of arriving at truth.

The traditions and history of the South were a favourite Faulkner theme. *Sartoris* (1929) and *The Unvanquished* (1938) tell the story of several generations of the Sartoris family. *The Reivers* (1962) is a humorous story of a young boy's adventures during a trip from Mississippi to Memphis, Tennessee. Faulkner examined the relationship between blacks and whites in several works, including *Light in August* (1932); *Absalom, Absalom!* (1936); and *Go Down, Moses* (1942). Here, he was especially concerned with people of mixed racial background and their problems in establishing an identity.

Most of Faulkner's novels have a serious, even tragic, tone. But in nearly all of them, tragedy is profoundly mixed with comedy. Faulkner's comic sense was the legacy of Mark Twain and other earlier writers. Twain was a direct influence on him. *The Hamlet* (1940), *The Town* (1957), and *The Mansion* (1959) make up the Snopes Trilogy. These novels form a tragicomic chronicle of the Snopes family and their impact on Yoknapatawpha County. Faulkner's short stories have the same range of technique, theme, and tone as his novels. His stories appear in *The Collected Stories of William Faulkner* (1950) and *The Uncollected Stories of William Faulkner* (published in 1979, after his death).

Faulkner was born in New Albany, Mississippi, and spent most of his life in Oxford, Mississippi. In 1929, he married Estelle Oldham, whom he had known since childhood. He worked occasionally in Hollywood as a film scriptwriter from 1932 to 1954.


William Faulkner

Many early critics of Faulkner denounced his books for their emphasis on violence and abnormality. *Sanctuary* (1931), a story involving rape and murder, was most severely criticized. Later, many critics recognized that Faulkner had been criticizing the faults in society by showing them in contrast to what he called the "eternal verities." These verities are universal values such as love, honour, pity, pride, compassion, and sacrifice. Faulkner said it is the writer's duty to remind readers of these values.

Fault. See **Earthquake** (Why earthquakes occur; illustration: An earthquake focus); **San Andreas Fault.**

Faun, was a half-human and half-animal spirit of the woods and herds in Roman mythology. The fauns corresponded to Greek satyrs. Like the satyrs, they enjoyed drinking, playing tricks, and chasing lovely maidens called *nymphs.*

Fauns were followers of Bacchus, the god of wine. The name faun comes from Faunus, whom the Romans identified with Pan, the Greek god of fields and woods. See also **Satyr.**


Bronze statue (A.D. 1-99) from Pompeii, Italy

A faun was a half-human god of the woods in Roman mythology. A faun commonly had pointed ears, short horns, and a tail.

Fauna is the name given to the animal life of a certain part of the world or of a certain period of time. It corresponds to the word *flora,* which means the plant life of a certain place or time. Thus we may speak of the fauna and flora (animals and plants) of North America or of a past geological period.

The term *fauna* comes from the name of a Roman goddess of fields and flocks.

Fauré, Gabriel Urbain (1845-1924), was a French composer. He was an important composer of French songs and *song cycles* (series of songs). Fauré also composed extensively for solo piano and for chamber groups. Fauré's style is characterized by his adventurous use of harmony.

Fauré's major compositions include *Requiem* (1900), a work for chorus and orchestra; and two song cycles, *La Bonne Chanson* (1894) and *La Chanson d'Eve* (1906-1910). Fauré also wrote the orchestral suite *Pelléas et Melisande* (1898) and two operas, *Prométhée* (1900) and *Pénélope* (1913).

Fauré was born in Pamiers, near Toulouse, France. He worked primarily as a church organist until 1896, when he was appointed professor of composition at the Paris Conservatory. He served as director of the conservatory from 1905 to 1920.

Faust, also called Faustus, was a German astrologer and magician who became an important figure in legend and literature. Little is known about the historical Faust, but he probably lived from about 1480 to 1540. Germans of the time considered him a fraud and a criminal. Martin Luther, the founder of Protestantism, believed that Faust possessed devilish powers.

In 1587, a crude legendary biography appeared, called *The History of Johann Faust,* or the *Faustbook.* The unknown author borrowed many sensational legends about other magicians. In the *Faustbook,* Faust sells his soul to the devil Mephistopheles for 24 years in exchange for whatever he wishes. Faust flies throughout Europe performing magic, and finally goes to hell, horrified by his damnation. The book was translated into many languages and rewritten three times in the next 125 years.

The first artistic version of the *Faustbook* was *The Tragical History of Doctor Faustus* (about 1588), a verse tragedy by the English playwright Christopher Marlowe. In the play, Faustus is a scholar who yearns to know all human experience. He often wavers about his bargain with the devil and finally wants to repent, but he cannot.

Many popular plays and puppet shows about Faust appeared during the 1600's and 1700's, mainly in Germany. These works were influenced by Marlowe's tragedy, but they were gruesome and silly with little literary merit.

The greatest literary version of the Faust story was a poetic drama by Johann Wolfgang von Goethe, a German writer. Goethe wrote *Faust* in two parts (published in 1808 and 1832), changing the story radically. In Goethe's version, Faust is finally saved by God.

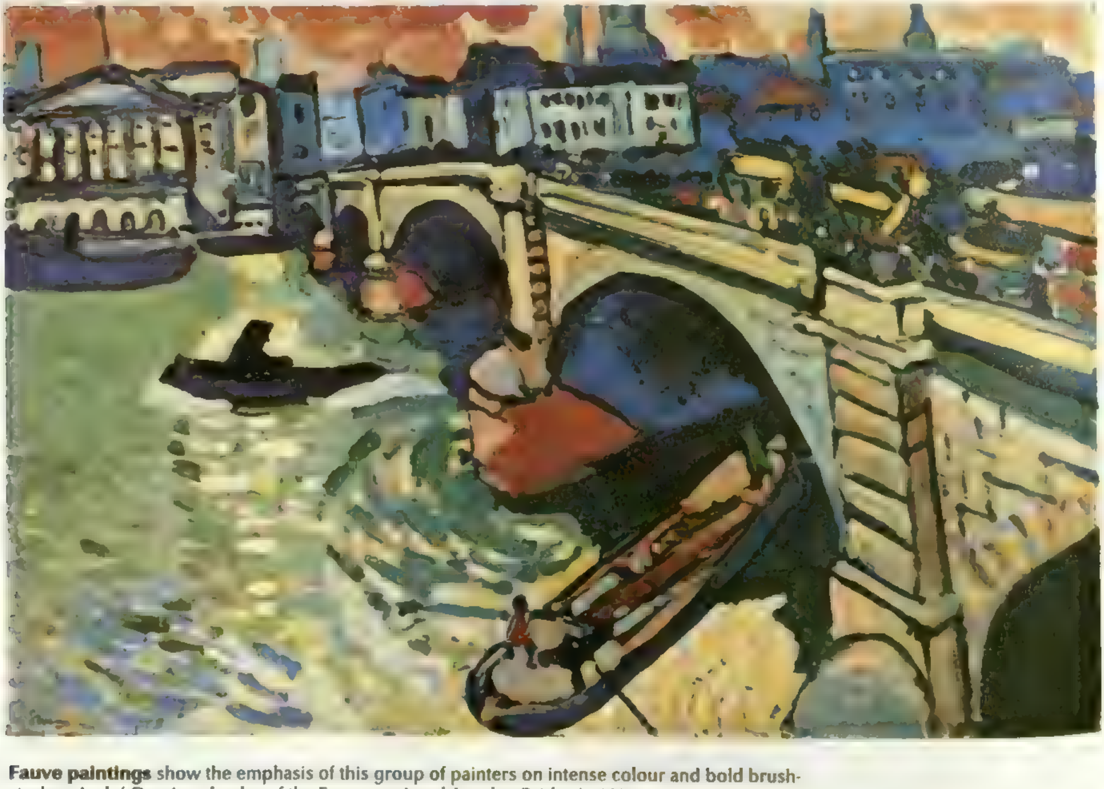
There have been many later versions of the Faust story. All were influenced by Goethe's interpretation, except that in each version Faust goes to hell. Dorothy Sayers of England, Thomas Mann of Germany, and Paul Valéry of France are among the writers who adapted the legend of Faust in their works during the 1900's.

See also **Goethe, Johann Wolfgang von; Mann, Thomas; Marlowe, Christopher; Mephistopheles; Opera** (*Faust*).

Fauves were a group of French artists who painted in a style that emphasized intense colour and rapid, vigorous brushstrokes. Fauvism flourished from about 1903 to 1907. Henri Matisse led the movement, and members included André Derain, Raoul Dufy, Maurice de Vlaminck, and Georges Rouault.

The Fauves tried to express as directly as possible the vividness and excitement of nature. The group was influenced by the bright colours, bold patterns, and brushwork of such artists of the 1880's and 1890's as Paul Cézanne, Paul Gauguin, Georges Seurat, and Vincent van Gogh.

The word *fauves* means *wild beasts* in French. An art critic gave the painters this name because of the unusual boldness of their style. Most of the Fauves had changed their style of painting by about 1907. But the movement had great influence throughout Europe, especially on German expressionism.



Fauve paintings show the emphasis of this group of painters on intense colour and bold brushstrokes. André Derain, a leader of the Fauves, painted *London Bridge* in 1906.

Each artist mentioned in this article has a biography in *World Book.* See also **Painting** (Fauvism).

Favenc, Ernest (1846-1908), was a British-born Australian explorer and author. In July 1878, Favenc, two other white men, and an Aborigine began to explore the country between Blackall, Queensland, and Darwin in the Northern Territory of Australia to find out whether a railway link between Queensland railways and Darwin was practicable. They discovered good pastureland. In 1887, Favenc settled down to literary work. He published about 10 works, including novels, books about Australia and its exploration, volumes of short stories, and verse. He was born in London and emigrated to Sydney in 1863.

Fawcett, Percy Harrison (1867-1925?), was an Englishman who explored the jungles of Brazil. He was an officer in the British army and a trained surveyor. In 1906, the Royal Geographical Society invited Fawcett to survey part of the frontier between Brazil and Bolivia. He spent 18 months in the jungle, in the Mato Grosso area, where he learned much about the tribes of the jungle. After World War I (1914-1918), Fawcett returned to Brazil. Fascinated by stories of a hidden city, he planned an expedition into the interior. In 1925, with his son Zack and a friend of his son, he led an expedition into the jungle. Nothing was heard of the party again. His younger son Brian wrote of Fawcett's experiences in *Exploration Fawcett* (1953). Fawcett was born at Torquay, in Devon, England.

Fawkes, Guy (1570-1606), was a member of the group of conspirators who plotted to blow up King James I of Great Britain and his Protestant Parliament on Nov. 5, 1605. This conspiracy is popularly known as the *Gunpowder Plot.* Fawkes and all of the other conspirators were Roman Catholics. They were fanatically opposed to the anti-Catholic policy of the Protestant Parliament. The penal code operated harshly against many Catholics. The conspirators were led by Robert Catesby, who hired a cellar beneath the Houses of Parliament and filled it with barrels of gunpowder. Guy Fawkes was to light the fuse. But the conspiracy was anticipated. Fawkes was caught and tried, and hanged on Jan. 31, 1606. Many British people celebrate Guy Fawkes day annually on November 5, by burning the *Guy* and letting off fireworks.

Guy Fawkes was born in York, England, of Protestant parents. He became a Roman Catholic at an early age. He left England to serve in the Spanish army in the Netherlands from 1593 to 1604.

Fawkner, John Pascoe (1792-1869), an Australian pioneer, was a cofounder of Melbourne. In August 1835, he led a party from Van Diemen's Land (now Tasmania) to settle on the shores of Port Phillip Bay, Victoria. They found a party led by John Batman already settled in the area. Batman died soon afterward, but Fawkner lived to see the colony gain self-government. Fawkner was born in London. In 1819, he settled in Launceston, Van Dieman's Land, where he established his own newspaper, the *Launceston Advertiser,* in 1829.

Fawn. See **Deer** (with picture).

Fax. See **Facsimile.**

FBI. See **Federal Bureau of Investigation.**

Fear. See **Emotion; Phobia.**

Feast of Weeks. See **Shavuot.**

Feasts and festivals are special times of celebration. Most take place once a year and may last for a day or more. Many feasts and festivals honour great leaders, saints, or gods or spirits. Others celebrate a harvest, the beginning of a season or of a year, or the anniversary of a historical event. Most feasts and festivals are joyous occasions, but some involve mourning and repentance.

During some feasts and festivals, adults stay away from their jobs, and children stay home from school. Some people celebrate happy events by decorating their homes and streets, wearing special clothes, and exchanging gifts. Many of these celebrations include the preparation of special meals, dancing, and parades. Solemn occasions may be observed with fasts, meditation, and prayer.

In the past, nearly all feasts and festivals were religious. Today, many of them celebrate nonreligious events. This article discusses feasts and festivals in five major religions. For a discussion of nonreligious celebrations, see **Holiday.**

In Christianity, the most important festivals recall major events in the life of Jesus Christ. These festivals include Christmas, which celebrates His birth; and Easter, which celebrates His Resurrection. Other Christian festivals honour the Virgin Mary, various saints, and the founding of the church.

Christians celebrate feasts and festivals both in church and at home. The celebrations differ widely among different groups. Many Protestants and Roman Catholics consider Christmas the most joyous and elaborate festival. Members of the Eastern Orthodox Churches regard Easter as their most important celebration. Some feasts and festivals are celebrated only in certain parts of the world. For example, a town may hold a festival for its patron saint.

In Judaism, the most sacred festivals are Rosh Ha-Shanah, the Jewish New Year; and Yom Kippur, the Day of Atonement. According to Jewish tradition, people are judged on Rosh Ha-Shanah for their deeds of the past year. On Yom Kippur, Jews fast, express their regret for past sins, and declare their hope to perform good deeds during the coming year.

Many Jewish festivals commemorate major events in Jewish history. For example, Passover celebrates the Exodus of the Jews from Egypt. Hanukkah is a celebration of a Jewish victory over the Syrians in 165 B.C. Purim honours the rescue of the Jews of Persia (now Iran) from a plot to kill them. Jews celebrate these festivals both in synagogues and at home.

In Islam. All followers of Islam, who are called Muslims, observe two celebrations—the Great Festival and the Lesser Festival. The Great Festival, or Festival of Sacrifice, traditionally takes place at the end of pilgrimages to the holy city of Mecca. During the Great Festival, which occurs in the last month of the Muslim year, Muslims sacrifice an animal and usually give the meat to the poor.

The Lesser Festival, or Festival of the Breaking of the Fast, marks the end of the month of Ramadan. During this month, Muslims fast from dawn to dusk. Many Muslims celebrate the birthday of the Prophet Muhammad and of various saints. Muslims who belong to the Shiite sect mourn the death of Husain, the grandson of Muhammad.

In Buddhism. Buddhists hold two principal kinds of festivals. The first type commemorates events in the life of Buddha—chiefly his birth, enlightenment, and death. Buddhists in different parts of the world observe these events in a variety of ways. In Japan, for example, Buddhists celebrate Buddha's birthday by decorating temples with flowers and pouring sweet tea over statues of the infant Buddha.

The second type of Buddhist festival honours the community of Buddhist monks. One such festival marks the end of the monks' annual retreat. During this celebration, groups of villagers perform a ceremony called the *kathina,* in which they give robes to the monks.

In Hinduism. Hindus hold festivals to honour each of the hundreds of Hindu gods and goddesses. Most of these festivals are local celebrations at the temples and honour specific divinities.

A few festivals are observed by all Hindus, chiefly in their homes and villages. These festivals, which include Holi and Diwali, combine religious ceremonies with feasts, fireworks, parades, and other traditional amusements. Holi, the spring festival, is a boisterous celebration in which people throw coloured water at one another. During the festival of Diwali, which honours the goddess of wealth and beauty, Hindus decorate their houses and streets with lights.

Related articles in *World Book* include:

Ash Wednesday
Assumption
Candlemas Day
Christmas
Doll (Doll festivals and customs)
Easter
Epiphany
Good Friday
Guadalupe Day
Halloween
Hanukkah
Holiday
Islam (Customs and ceremonies)
Judaism (Holy days and festivals)
Mardi Gras
Maundy Thursday
May Day
Michaelmas
New Year's Day
Olympic Games
Palm Sunday
Passover
Pentecost
Purim
Rosh Ha-Shanah
Sabbath
Saturnalia
Shabuot
Simhat Torah
Sukkot
Tishah be-av
Yom Kippur

Feather is one of the light, thin growths that cover a bird's body. Feathers consist chiefly of *keratin,* a substance also found in the hair of mammals and the scales of fish and reptiles. Unlike hair and scales, feathers have a complicated branching pattern.

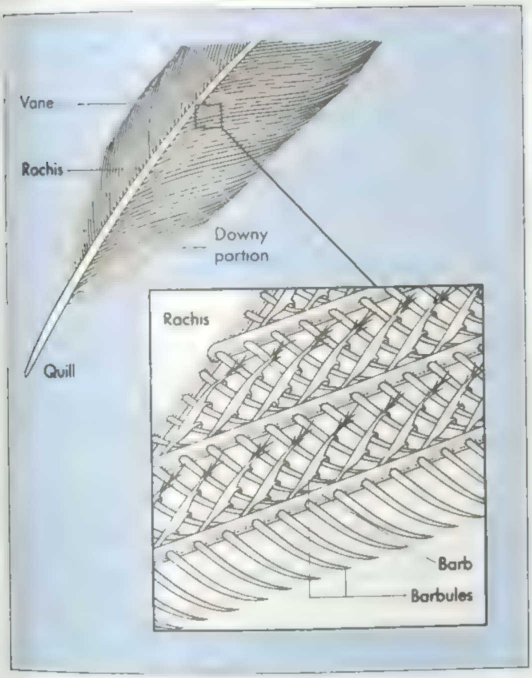
A Shinto religious festival in Kyoto, Japan, features a parade of giant floats. The festival started in A.D. 876.

A religious procession by villagers in Sri Lanka honours the birthday of Buddha, the founder of their religion, Buddhism.

Local fairs called *ferias* are held throughout Spain and Latin America. The Spanish feria above celebrates a grape harvest.

Guadalupe Day is Mexico's most important religious festival. People wear colourful Indian costumes on this holiday.

Parts of a contour feather



Kinds and parts of feathers. Birds have two principal kinds of feathers: (1) contour and (2) down. The parts of a feather differ somewhat, depending on the kind of feather.

Contour feathers grow on a bird's body only in special areas called *pterylae*. From the pterylae, the relatively large contour feathers fan out to cover the bird almost completely.

A typical contour feather has a broad, flat *vane* attached to a long central *shaft*. The shaft consists of two parts. A hollow, rounded base of the shaft, called the *calamus* or *quill*, extends from the bird's skin to the vane. The solid, tapering upper part of the shaft, called the *rachis*, runs through the vane. The vane is formed by *barbs* that branch from the sides of the rachis and *barbules* that branch from the barbs. Hooks on the barbules link neighbouring barbs, giving the vane both strength and flexibility. A sudden blow to the vane is more likely to separate the hooks from neighbouring barbs than to tear or break the feather. The bird can refasten the hooks by pressing the barbs together with its beak. This is called *preening*.

Down feathers, unlike contour feathers, grow all over a bird's body. They have an extremely short rachis, so the barbs branch from almost the same point near the top of the shaft. The barbules of a down feather have no hooks. Thus, the vane is loose and fluffy.

Functions of feathers. Feathers enable a bird to fly and help it maintain a constant body temperature. Feathers also may provide colouring that helps the bird hide from its enemies or attract a mate. Although feathers are remarkably durable, they gradually wear out. Birds shed their feathers and grow a new set at least once a year. This process is called *moulting*.

How people use feathers. People have used feathers for a variety of purposes. Until the mid-1800's, when pens with steel points became popular, most people wrote with quill pens. Today, manufacturers use feathers as stuffing in pillows and furniture. Down feathers provide excellent insulation in jackets, quilts, and sleeping bags. Designers decorate hats and other garments with feathers.

Some uses of feathers, however, have come under heavy criticism. For example, the overuse of feathers for women's hats has endangered the survival of some birds, for example egrets.

Related articles in *World Book* include:

Bird (Feathers; picture: External features)	Bird of paradise	Peacock
	Egret	Pen
	Ostrich	Pheasant

Feather, Lord (1908-1976), Victor Grayson Hardie Feather, was General Secretary of Britain's Trades Union Congress (TUC) from 1969 until 1973. He had been Assistant General Secretary since 1960. Feather served on the royal commission appointed in 1966 to inquire into English local government. He also served on various government-appointed bodies, such as the National Economic Development Council and the Forestry Commission.

Feather was born in Bradford, England. He worked for the Co-operative Retail Society from 1923 to 1937 and started his trade union career, holding voluntary offices. In 1937, he joined the staff of the TUC.

Feather star. See Sea lily.

Feather-tail gliders, also known as *pygmy gliders*, are the smallest marsupials able to make gliding flights. Their bodies are only about 7 centimetres long. They have gliding membranes and featherlike tails. They are common in the eucalypt forests of eastern Australia, but are rarely seen because they come out only at night.

Scientific classification. The feather-tail glider belongs to the family Phalangeridae. It is *Acrobates pygmaeus*.

A feather-tail glider is a tiny opossum that feeds on insects and the nectar of blossoms. The feather-tail glider is pictured on the Australian one-cent coin.

February is the second month of the year according to the Gregorian calendar, which is used in almost all countries of the world today. It is also the shortest month. According to legend, the first calendar of the ancient Romans had only 10 months. In about 700 B.C., the ruler Numa Pompilius added two months, making February the last month of the year. The month takes its name from the Latin word *februare,* meaning *to purify.* The Romans purified themselves in February to prepare for festivals at the start of the new year. In 46 B.C., the Roman statesman Julius Caesar moved the beginning of the year from March to January, making February the second month.

February usually has 28 days. But it has one extra day in every leap year. February had 30 days until the time of Julius Caesar. Caesar took one day off to add to the month named after him, July. According to tradition, the Roman emperor Augustus took another day off to add to August, the month named after him.

February is usually cold and stormy in the northern half of the world. But sunny days now and then show that spring is not far off. February is not nearly so dark and gloomy as the other winter months. The air is often crisp and clear. People in the Southern Hemisphere enjoy mid-summer weather during February.

Special days. People in most Western countries celebrate Valentine's Day on February 14. Many people send valentine cards, usually unsigned, to friends they particularly like. The custom of exchanging greetings on Valentine's Day goes back hundreds of years. Scholars have found records of Valentine notes that date from the 1400's.

The Roman Catholic Church celebrates February 2 as Candlemas Day. The candles used in the church during the rest of the year are blessed on February 2.

Two of America's greatest leaders, George Washington and Abraham Lincoln, were born during February. So too were Thomas More, the chancellor of England; and the Commonwealth statesmen Harold Macmillan of Britain and Walter Nash of New Zealand.

Important February events

1 First balloon ascent in Australia, 1858.
— Louis S. St. Laurent, French-Canadian prime minister of Canada, born 1882.
— Return to Iran of exiled Islamic leader Ayatollah Khomeini, 1979.
2 Charles Sturt discovered Darling River, Australia, 1829.
— New Zealand's first railway, the Don Mountain line, opened in Nelson, 1862.
— James Joyce, Irish novelist and poet, born 1882.
— Violinist Jascha Heifetz born 1901.
— The last German troops surrendered in the Stalingrad pocket, completing the Soviet Union's victory at Stalingrad, during World War II, 1943.
3 German composer Felix Mendelssohn born 1809.
— Elizabeth Blackwell, first modern woman doctor, born 1821.
— Soviet Luna 9 spacecraft landed on the Moon, 1966.
4 Confederate States of America organized by a temporary committee that met at Montgomery, Alabama, U.S.A., 1861.
— Philippine rebellion against the United States began, 1899.
— Charles A. Lindbergh, American aviator who made the first solo flight across the Atlantic Ocean, born 1902.
— Yalta Conference began, 1945.
— Ceylon (now Sri Lanka) gained its independence, 1948.
5 British prime minister Sir Robert Peel born 1788.
6 Queen Anne of England born 1665.
Sir Henry Irving, British actor, born 1838.
— Waitangi Day, holiday in New Zealand.
6 American baseball player "Babe" Ruth, the "home run king", born 1895.
— Ronald Reagan, president of the United States, born in Tampico, Illinois, U.S.A., 1911.
— Princess Elizabeth became Queen Elizabeth II of the United Kingdom, 1952.
— Sir Thomas More, chancellor of England, born 1478.
7 British novelist Charles Dickens born 1812.
— Sir George Russell Drysdale, Australian painter, born 1912.
— Grenada became independent, 1974.
8 Mary, Queen of Scots, executed, 1587.
— John Ruskin, English essayist and critic, born 1819.
— William T. Sherman, Union Army general in the American Civil War, born 1820.
— Jules Verne, French novelist, born 1828.
— Russo-Japanese War began, 1904.
9 Australian aviator Charles Kingsford-Smith born 1897.
10 France surrendered Canada to Great Britain by the Treaty of Paris, 1763.
— English essayist and critic Charles Lamb born 1775.
— British prime minister Harold Macmillan (later the Earl of Stockton) born 1894.
11 Thomas A. Edison, American inventor, born 1847.
12 Thaddeus Kosciusko, Polish patriot, born 1746.
— Abraham Lincoln, president of the United States, born near present-day Hodgenville, Kentucky, U.S.A., 1809.
— Charles Darwin, British naturalist, born 1809.
Marie Lloyd, British music hall star, born 1870.
— Walter Nash, New Zealand statesman, born 1882.
13 Massacre at Glencoe, Scotland, 1692.


Feb. birthstone—amethyst


Feb. 4—Sri Lanka gained independence


Feb. 6—Elizabeth II becomes queen of the United Kingdom


Feb. 12—Charles Darwin born

Popular beliefs. In leap years, according to one old custom, women can propose marriage to the man of their choice on February 29. In the United States, February 2 is known as Ground-Hog Day, from the old belief that the ground hog, or woodchuck, comes out of its burrow on that day to see whether the sun is shining. If the sun is shining, so the story goes, the animal begins its springtime activities.

February symbols. Many people consider the primrose the special flower for February. The amethyst is the birthstone for February.

Quotations

The February sunshine steeps your boughs,
And tints the buds and swells the leaves within.
William Cullen Bryant

I crown thee king of intimate delights,
Fireside enjoyments, home-born happiness,
And all the comforts that the lowly roof
Of undisturb'd retirement, and the hours
Of long uninterrupted evening know.
William Cowper

Hail to thy returning festival, old Bishop Valentine!
Like unto thee, assuredly, there is no other mitred father in the calendar.
Charles Lamb

If February give much snow
A fine summer it doth foreshow.
English rhyme

Thirty days hath September,
April, June, and November;
All the rest have thirty-one,
Excepting February alone
Which hath but twenty-eight, in fine,
Till leap year gives it twenty-nine.
Old saying

Related articles in *World Book* include:

Amethyst
Calendar
Candlemas Day
Leap year
Primrose
Valentine's Day

Important February events

13 Joseph Banks, botanist who sailed with Captain Cook, born 1743.
— Talleyrand, French statesman, born 1754.
— Grant Wood, American painter, born 1891.
14 Valentine's Day.
— Death of Captain James Cook, British navigator, 1779.
— John Barrymore, American actor, born 1882.
15 Galileo, Italian astronomer and physicist, born 1564.
— American inventor Cyrus McCormick born 1809.
— Polar explorer Sir Ernest Shackleton born 1874.
— Surrender of Singapore to Japanese forces, 1942.
— The United Kingdom switched from pounds, shillings, and pence to decimal currency, 1971.
16 British Historian G.M. Trevelyan born 1876.
— Fidel Castro became prime minister of Cuba, 1959.
17 Thomas Robert Malthus, British economist, born 1766.
— First official air mail between Australia and New Zealand, 1934.
18 Mary I, queen of England, born 1516.
— John Bunyan's *Pilgrim's Progress* was licensed for publication, 1678.
— Jefferson Davis took the oath as provisional president of the Confederate States of America, 1861.
19 Polish astronomer Nicolaus Copernicus born 1473.
— David Garrick, English actor, born 1717.
— Thomas A. Edison patented the phonograph, 1878.
20 Astronaut John H. Glenn, Jr., became first American to orbit the earth, 1962.
21 George Lansbury, British socialist, born 1859.
— British poet W.H. Auden born 1907.
22 George Washington, first president of the United States, born in Westmoreland County, Virginia, U.S.A., 1732.
— German philosopher Arthur Schopenhauer born 1788.
— The United States acquired the Florida territory from Spain, 1819.
— Robert Baden-Powell, founder of Scout movement, born 1857.
— Norman Lindsay, Australian artist and writer, born 1879.
23 Samuel Pepys, English diarist, born 1633.
— English composer George Frideric Handel born 1685.
— First regular radio broadcasts in Britain, 1920.
24 Winslow Homer, American painter, born 1836.
25 José de San Martín, liberator of Argentina, Chile, and Peru, born 1778.
— Enrico Caruso, Italian singer, born 1873.
— President Ferdinand Marcos of the Philippines resigned from office and fled the country, 1986.
26 Victor Hugo, French poet and novelist, born 1802.
— Napoleon escaped from island of Elba, 1815.
— American frontiersman and showman William Frederick Cody, better known as "Buffalo Bill," born 1846.
27 Henry Wadsworth Longfellow, American poet, born 1807.
— Battle of Majuba Hill, South Africa led to independence of the Transvaal under Paul Kruger, 1881.
— British Labour Party founded 1900.
28 Russian dancer, Vaslav Nijinsky, born 1890
— Stephen Spender, British poet, born 1909.
29 Marquis de Montcalm, French commander in Quebec, born 1712.
— Gioacchino Antonio Rossini, Italian composer, born 1792.


Feb. 13—Glencoe massacre, Scotland


Feb. 14—Valentine's Day


Feb. 22—George Washington born


Feb. 23—George Frideric Handel born

Federal Bureau of Investigation (FBI) is the chief investigating branch of the United States Department of Justice. FBI investigators are called *special agents.*

A director, appointed by the President with the approval of the Senate, supervises the FBI from headquarters in Washington, D.C. The FBI has about 60 offices in the United States and Puerto Rico and 15 offices in other countries, including Russia, where it opened an office in 1994. It employs more than 23,000 men and women, of whom about 9,500 are special agents. It has an annual budget of about 1.5 billion U.S. dollars.

FBI operations

Criminal investigation. The FBI investigates such federal crimes as assault on the President, bank robbery, bombing, hijacking, and kidnapping. It handles cases involving stolen money, property, or vehicles that have been taken from one state to another. The bureau fights organized crime and, at the request of state or local authorities, it helps capture fleeing criminals. The FBI also examines reported violations of civil rights laws. In addition, it works with the federal Drug Enforcement Administration to investigate violations of federal criminal drug laws. In all criminal investigations, the FBI gives its findings to the Justice Department.

Intelligence operations of the FBI consist of gathering information about individuals or organizations engaged in activities that may endanger national security. These operations include the investigation of rebellions, riots, spying, treason, and threats to overthrow the government. The FBI reports to the President, Congress, or the Justice Department.

Other services. The FBI provides various services to law enforcement agencies throughout the United States and in other countries. Such agencies may request help from the FBI Identification Division, the FBI Laboratory, and the National Crime Information Centre (NCIC).

The FBI Identification Division has the world's largest collection of fingerprints. Its files contain about 169 million prints. The FBI Laboratory is one of the world's finest crime laboratories. FBI scientists examine over 600,000 pieces of evidence each year, including bullets, handwriting samples, and tyre prints. The NCIC is a computerized information system that stores almost 5 million records concerning criminal suspects and stolen property. The FBI Academy in Quantico, Virginia, provides training in advanced methods of fighting crime.

History

In 1908, Attorney General Charles J. Bonaparte organized a group of special investigators in the Justice Department. This group, called the Bureau of Investigation, investigated such offences as illegal business practices and land sales. Congress gave the bureau its present name in 1935. A wave of bank robberies, kidnappings, and other violent crimes broke out in the United States during the 1930's. Congress passed laws giving the FBI increased authority to combat this lawlessness.

During World War II, the FBI broke up enemy spy rings in the United States. In the 1950's and 1960's, special agents arrested Communist spies who had stolen secret atomic and military information. The bureau also investigated protest organizations in the 1960's and early 1970's. See also **Hoover, J. Edgar; Crime.**

Federal district is a tract of land that a country sets apart as the seat of its national capital. The U.S. District of Columbia is a federal district. Other countries that have a federal district include Australia, Brazil, Malaysia, Mexico, and Venezuela. In Australia, it is called a *capital territory* and in Malaysia it is known as a *federal territory.* See also **Canberra; Mexico City; Washington, D.C.**

Federal government. See **Federalism.**

Federal style. See **Furniture** (Early American furniture; picture: The Federal style).

Federalism is a system in which political power is divided between a *central* (national) government and smaller governmental units. The central government is often called the *federal government,* and the smaller units, *states* or *provinces.* The division of powers is usually defined in a constitution. The United States, Canada, Australia, and Switzerland have federal systems. To a degree, so do Mexico and India.

Federal systems of government differ from *unitary* systems. In a unitary system, all power legally derives from the central government. States or provinces have only those powers that the central government gives them. Some countries that appear to use the federal system really use the unitary system. Their provinces are administrative units rather than political units with separate powers.

In a true federal system, some powers are constitutionally reserved for the states or provinces. The central government has direct authority over the people concerning powers granted to it in the constitution. This feature distinguishes a federal system from a loose grouping of states, commonly called a *confederation.* A confederation can only act through its individual member states.

See also **Government;** and the *Government* section of the countries mentioned.

Federation of Australia dates from 1901, when the six Australian colonies became states of the Commonwealth of Australia. Several methods of combining the colonies had been tried unsuccessfully before 1889. In that year, Sir Henry Parkes, the premier of New South Wales, urged the colonists to form a federal union. During the 1890's, many attempts to federate failed. Colonial representatives met in 1891, 1893, 1898, and 1899. In 1899, a drafting committee drew up the federal Constitution and the Australian people voted in favour of federation. The Duke of York, later King George V, proclaimed the Commonwealth of Australia on Jan. 1, 1901.

The first phase

Self-government. Fifty years after the British government had sent the first convicts to the penal settlement on the eastern coast of Australia, colonists in five different areas of the continent began seeking self-government. By 1850, the British government was prepared to grant their request. The possibility of a federal government was also considered, but the colonists also wanted independence from one another.

Between 1855 and 1859, New South Wales, Victoria, Tasmania, South Australia and Queensland gained "responsible government." This meant that they each had their own elected governments. Only the western third of the continent, where the colonists still wanted to maintain the convict system, was under British control.

Western Australia remained virtually a crown colony until 1890.

Problems of separate development. From 1863 to 1880, intercolonial conferences discussed matters requiring cooperative effort. Already the difficulties caused by development without full consultation had become apparent. For example, New South Wales had constructed its railway system with a different gauge from those of its neighbours.

But none of the colonial leaders was prepared to sacrifice his own colony's interests for the good of the other's. The weaker colonies feared the strong ones and the strong ones were jealous of one another. They were fully in agreement only on defence. They all believed Britain should protect them against any external threat.

The second phase (1880-1889)

Growing national awareness. By 1880, Australia's population had passed the 2 million mark. About 60 per cent of these people had been born in Australia and about 34 per cent were immigrants from Britain.

During the 1880's, several issues came up that needed united action. The first of these was the need the colonial governments felt to restrict Chinese immigration. Another important issue was the *blackbirding* (kidnapping) of South Sea Islanders to work on the sugar and cotton plantations in Queensland.

The colonial governments also feared European expansion into islands close to Australia. One of Sir Thomas McIlwraith's last actions as Queensland's premier was to annex New Guinea, to forestall German designs on Papua. The Australian colonies felt that if Britain did not act on their behalf, then they should act themselves. Parkes proposed in 1880 that the colonies consider some form of permanent intercolonial legislative body. James Service, the premier of Victoria, called for an intercolonial conference. It was organized before the end of 1883. Sir Samuel Griffiths, the premier of Queensland, drew up a draft constitution for a federal council. Britain gave its consent in 1885. It authorized the Australian colonies, plus New Zealand and Fiji, to be represented at the first meeting of the Federal Council in 1886.

New Zealand was not represented. Fiji and Western Australia each sent one representative. South Australia, Victoria, and Queensland each sent two. But the representatives of New South Wales did not appear. Sir Henry Parkes had decided that the proposed body would hinder rather than aid the federation movement.

The fiscal problem. The absence of New South Wales, the oldest, and in most ways the strongest, colony, hindered the work of the Federal Council. But the greatest obstacle to the achieving of federation was known as the *fiscal problem.* Colonists in Victoria strongly believed in import duties to protect the colony's manufacturers against the competition of goods not made in Victoria. The people of New South Wales were equally firm in their belief that trade should be free.

The fiscal argument as to which policy was better, protection or free trade, divided New South Wales and Victoria on the question of federation. It also divided New South Wales and Victoria into political parties. Another area of conflict arose over the matter of financing a federal body. Everybody knew that this revenue would be gained by imposing taxes on goods coming into Australia. New South Wales colonists wanted to limit such tariffs. The colonial governments also needed revenue to manage their own affairs. They did not want a federal government to take most of the revenue. Raising and spending its own money seemed an essential part of self-government for every colony. The fiscal problem was always in the background in intercolonial meetings.

There were other difficulties. The Federal Council could make laws, but the laws required approval by both the British government and the governments of the colonies. The council had to depend on the colonial governments to carry them out. It could not raise any revenue, and could not, under any conditions, take action independently of the colonial governments. But the Federal Council did begin to popularize the idea of federation throughout Australia.

Sir Henry Parkes reentered the federation campaign in 1889. At Tenterfield, in New South Wales, he made a widely publicized speech calling on all Australians to work for the establishment of a central parliament with executive powers.

Sir Henry Parkes is often called the *Father of Federation* because of his long campaign to persuade the Australian states to unite. He died before federation was finally achieved in 1901.

The third phase (1891-1893)

The preliminary conference organized by Sir Henry Parkes took place in Melbourne in 1890. It was a profound success. Elected delegates and invited guests included strong supporters of federation. James Service, the former Victorian premier, was present. Duncan Gillies and Alfred Deakin, leaders of Victoria's coalition government, were also there. Deakin was a future prime minister. Edmund Barton, another future prime minister, represented New South Wales with Parkes. Sir Samuel Griffith was one of the Queensland representatives. Inglis Clarke came from Tasmania. All the colonies, as well as New Zealand, had sent delegates. When Parkes spoke at the banquet that opened the conference, he was greeted with great applause. However, he became too ill to participate in the conference.

The delegates agreed that an Australian federal government with powers to make laws and carry them out should be established. They decided to ask the colonial governments to appoint members to a formal National Australasian Convention in 1891. The plans and the constitution would be drawn up at that meeting.

The first federal convention took place in Sydney early in 1891. All the colonies, as well as New Zealand,

Sir Edmund Barton was a leader of the federal movement in the 1890's. When Australia became a federation in 1901, Barton became the first prime minister.

A special menu was printed for the banquet in Sydney that celebrated the federal convention in 1897.

were represented. There were 46 delegates, all experienced politicians. A large number of premiers and former premiers attended. Nearly all of the members of the 1890 conference were present.

Parkes presided at first. But ill health again forced him to retire from the proceedings. Sir Samuel Griffith took his place. Griffith, representing Queensland; Edmund Barton, from New South Wales; Inglis Clarke, from Tasmania; and Charles Cameron Kingston, from South Australia, drew up the constitution. They were all experienced in both politics and law.

The first draft of the constitution proposed a federal government in the Commonwealth of Australia, consisting of six states instead of six colonies. It was altered beyond recognition over the next 10 years. But it provided a firm base for all the future negotiations. As leader of the drafting committee, Sir Samuel Griffith is recognized by historians as one of the great architects of federation in Australia.

After the 1891 proceedings were completed, the colonial governments had to agree to the decisions made and endorse the constitution. Victoria and South Australia adopted the proposals, despite misgivings. But New South Wales caused difficulties. Parkes faced opposition, even inside his own party, concerning the clauses on finance and trade. He decided not to put the matter before his parliament. The other colonies then felt that there was no point in continuing. Throughout Australia, the colonial governments were facing the effects of economic depression. Industrial disputes and financial hardships in the colonies drew more concern than federation.

Parkes himself was defeated in the New South Wales elections of 1891. He stayed in parliament but died without regaining the premiership.

The fourth phase (1893-1897)

Federation becomes a popular movement. Edmund Barton, who was to be the first prime minister in Australia's federal government, began a campaign for federation in 1893. He toured New South Wales, appealing to the members of all electorates to support the cause of federation. Federal leagues began to spring into existence. They were aided by Barton's enthusiasm and advice. A similar movement gained momentum in Victoria. A group of professional and business people, called the *Australian Natives' Association,* fostered this movement. These parallel campaigns succeeded so well that federal leagues from both colonies were able to call a conference in 1893. It took place at Corowa, on the border of Victoria and New South Wales.

The Corowa Conference had no official parliamentary standing. But it provided a lead for the colonial parliaments to follow. Its main proposals were put forward by a lawyer, John Quick. He proposed that another convention should take place. The members of this convention were to be representatives, elected by the people. Quick also proposed that each colony should hold a referendum on the draft constitution.

The newly elected premier of New South Wales, George Reid, took up Quick's suggestion in 1894. The other premiers joined him in a conference in 1895. At this conference, they reached an agreement to hold a convention of elected representatives from all colonies.

The final phase (1897-1900)

Victory for federation. The decisive convention took place in three sessions, held during 1897 and 1898. Unfortunately, Queensland was not represented. The debate about the separation of the northern area of that colony had prevented the election of delegates. But the other colonies sent 10 representatives each. All delegates were elected directly from the people, except those from Western Australia, who were chosen by parliament. New Zealand was no longer concerned.

The invitation to the celebration of the first Australian federal Parliament on May 9, 1901, displayed elegant decoration.

Lord Hopetoun was sworn in as Australia's first governor-general at the inauguration ceremony at Centennial Park, in Sydney, on Jan. 1, 1901.

The 1897-1898 national convention redrafted the constitution and then submitted it in referendum form in four colonies. Neither Queensland nor Western Australia took part. A majority favoured the constitution in all the other colonies. But the majority in New South Wales was too small to satisfy either its government or the other colonies. Further amendments, drafted to satisfy the New South Wales government, were made at a premiers' conference.

All colonies participated in a second referendum in 1899. All recorded majorities. The government of Western Australia attempted to get further concessions but came in at the last moment. Finally, all the colonies were prepared to become states in a federal system consisting of five parts. They decided that a House of Representatives would represent all the electorates equally. The Senate was to represent the six states equally. An executive, consisting of the prime minister and Cabinet, was to be elected by the majority party. A High Court was to be set up to interpret the Constitution. A governor-general was to represent the British monarchy. The Australian Commonwealth flag, instead of being the British Union Jack, would have a small replica of the British flag in one quarter and six stars representing the Southern Cross and the six states. The British government consented to these proposals.

The powers of the federal Parliament were limited to a defined list. The states maintained their powers over all the areas not listed as federal powers. The main source of federal revenue would come from customs duties. But interstate trade would be free.

The founding fathers. The new federal Constitution was proclaimed and the Commonwealth of Australia came into being amidst great rejoicing on Jan. 1, 1901. Not all the founding fathers were in the first federal Parliament. Death or ill health had removed some of them, including Parkes and Service. Griffith had become Queensland's chief justice and was to be the chief justice of the High Court. Inglis Clarke had become chief justice in Tasmania. Barton became the first prime minister of Australia. Other supporters of federation, such as Deakin, Kingston, and Quick, were in the first Parliament.

Some people had opposed federation until late in the century. These people included George Reid, who was leader of the opposition. Sir John Forrest, another member of the federal government, had stopped Western Australia's entry until the last possible moment. Joseph Cook, a future prime minister, had also opposed federation. Other future prime ministers in the first federal government were John Watson, Andrew Fisher, and William Morris Hughes.

Related articles in *World Book* include:

Australia, Government of	Griffith, Sir Samuel Walker
Australia, History of	Parkes, Sir Henry
Deakin, Alfred	Service, James

Federation wheat was a popular wheat variety bred in Australia between 1894 and 1901 by William Farrer. Farrer worked at Lambrigg, his farm near Tharwa, now in the Australian Capital Territory.

Federation was a cross between *Purple Straw* and *Yandilla*, itself produced by crossing *Canadian Improved Fife* with an Indian variety, *Etawah*. It yielded well and consistently in southern temperate zone regions. It resisted storm damage, drought, and the fungus disease known as *rust*. Its short straw suited strip harvesting, but its qualities when baked were poor. Its high yield made it possible to extend the wheat belt into previously marginal land.

Federation wheat was introduced to the United States in 1914. It was later replaced by a disease-resistant variety called *White Federation*. By 1938, its influence had declined.

See also **Farrer, William.**

Feed is a term for food given to farm animals. *Roughage feeds* (coarse foods) that are used include soybeans, cowpeas, and pasture plants such as grass and alfalfa. Some of these plants are dried and fed to livestock as hay. Farmers often preserve whole maize plants and other crops, and use them as a feed called *silage*. Grains of maize, grain sorghum, or barley can be ground and mixed with other ingredients to make another kind of feed.

Farmers also give livestock extra and unused products from milling, brewing, meat packing, and other industries. Farmers give animals a combination of feeds to make sure the livestock get the nutrients necessary for good health. Feed is particularly important in winter, when there is little or no pasture on which livestock can graze.

Related articles in *World Book* include:

Agriculture	Dairying (Feeding)	Maize (Livestock feed)
Alfalfa	Grain	Pig (Raising pigs)
Cattle (Feeding)	Grass	Silo
Chicken	Hay	Soybean
Cotton (Uses)		

Feed crop. See **Agriculture** (Processing and storage).

Feedback. See **Automation; Cybernetics.**

Feet. See **Foot.**

Feininger, Lyonel (1871-1956), was an American painter whose works combine qualities of cubism and expressionism. The subject matter of his mature work is based on nature, and is characterized by flat crystalline planes of colour and thin straight lines.

Feininger was born in New York City. His parents were musicians. In 1887, he went to Germany to join his parents, who were on tour. Feininger stayed in Europe and was a political and satirical cartoonist in Berlin and Paris from 1894 to 1908. He then turned to painting and soon earned an international reputation for his work while living in Germany. In 1919 Feininger became the first professor chosen by Walter Gropius for the Bauhaus school of art and design in Germany. He returned to the United States in 1937, after the Nazis labelled him a "degenerate artist."

See also **Bauhaus.**

Feisal. See **Faisal.**

Feldspar is any of the most abundant group of minerals on the surface of the earth. These minerals make up about 60 per cent of the earth's crust. Feldspars occur in most *igneous rocks* and in many *metamorphic* and *sedimentary rocks* (see **Rock**). Extremely large feldspar crystals are found in a coarse-grained igneous rock called

Oil painting (1930); Neue Staatsgalerie, Munich, Germany

Feininger's *The Market Church in Halle* shows how the artist used straight lines to divide forms and space into flat planes.

pegmatite. Feldspars rank among the hard minerals (see **Hardness**). Feldspars range in colour from clear white or grey to shades of blue, green, or pink.

All feldspars contain alumina and silica. Feldspars may be classified into two general groups, *alkali feldspars* and *plagioclase feldspars,* according to the other elements they contain. All alkali feldspars contain potassium and most contain sodium. The most common minerals in this group are *microcline, orthoclase,* and *sanidine.* Most plagioclase feldspars, such as *andesine* and *labradorite,* contain both sodium and calcium. Some feldspar crystals, called *perthites,* consist of alkali and plagioclase feldspars.

Feldspar is used in making glass and ceramics. Feldspar crystals of especially beautiful colour and lustre may be used as gemstones, ornaments, and architectural decorations. The most popular of these crystals are *moonstone* (milky-white perthite), *Amazon stone* (green microcline), and labradorite, which is *iridescent* (displaying changing colours).

A process called *weathering* changes feldspars into other minerals, chiefly clay minerals and salts. *Kaolin,* the most important of these clay minerals, is used in making fine chinaware. Clay formed from feldspar is also used in the production of paper.

See also Earth (Weathering); **Granite; Moonstone; Crystal** (picture).

Fellahin. See Egypt (Rural life).

Fellini, Federico (1920-1993), was a famous Italian film director. He originated his own ideas for his films, usually developing the story as the film was being made. Many of his films blend realism and social satire with fantasy. They rely heavily on the use of symbolism and imagery, which create dreamlike sequences that are sometimes deliberately obscure.

Fellini was born in Rimini, Italy. As a child, he ran away to the circus for a few days, and the experience inspired much of his work. He collaborated with Alberto Lattuada on his first film, *Variety Lights* (1951). Fellini's first international success, *La Strada* (1954), won an Academy Award as best foreign film and established his wife, Julietta Masina, as a star. This grimly realistic, yet poetic film describes the relationship between a brutal circus strongman and a half-witted young girl.

Fellini's *La Dolce Vita* (1959) is an autobiographical and complex study of moral corruption in Italian society of the day. He also used autobiographical material in *8½* (1963). *Amarcord* (1974) won another Academy Award as best foreign language film. Fellini's other major films include *I Vitelloni* (1953), *Nights of Cabiria* (1957), *Juliet of the Spirits* (1965), *Fellini's Roma* (1972), and *The City of Women* (1979). In 1993, Fellini was awarded a special Academy Award for lifetime achievement in the film industry.

Felt is a fabric made of wool fibres or animal hair matted together by steam and pressure. Felt varies greatly in weight, thickness, and value. Manufacturers use felt to make hats, blackboard erasers, rug pads, slippers, and billiard-table covers. Felt is usually made in strips about 1.8 metres wide.

Female. See **Reproduction; Sex.**

Feminine gender. See Gender.

Feminism is the belief that women should have economic, political, and social equality with men. The term *feminism* also refers to a political movement that works to gain such equality. This movement is sometimes called the *women's liberation movement* or *women's rights movement.*

Feminism, the movement to gain equal rights for women, concentrated at first on winning *suffrage,* the right to vote. In 1915, women marched in a suffrage parade in New York City, *above.*

Feminist beliefs have existed throughout history, but feminism did not become widespread in Europe and the United States until the mid-1800's. At that time, many people regarded women as inferior and less important than men. They believed a woman's place was in the home. The law reflected this opinion. For example, women were barred by law from voting in elections or serving on juries. Most institutions of higher education and most professional careers were closed to women. Despite opposition, feminism grew in power during the 1800's and 1900's and won a number of new rights for women. Many people regard the feminist movement—and the resulting changes in the status of women—as a turning point in the history of society.

One of the first feminist books was *A Vindication of the Rights of Woman* (1792) by the British writer Mary Wollstonecraft. In this book, Wollstonecraft described the state of ignorance in which society kept women. She also pleaded for better educational opportunities. Another early feminist writer was the American antislavery leader Sarah M. Grimké. She wrote a pamphlet called *Letters on the Equality of the Sexes and the Condition of Woman* (1838). Grimké presented a powerful argument against religious leaders, who claimed to find support in the Bible for the inferior position of women.

At first, the feminist movement concentrated on gaining legal equality—especially the right to vote, called *suffrage.* In 1893, women in New Zealand were the first to win this right. They were followed by women in Australia, many European countries, and the United States during the early 1900's.

The feminist movement nearly disappeared after women had received the right to vote. During the mid-1900's, however, increasing numbers of women entered the labour force. They found that many high-paying jobs were closed to them. Feminist groups fought to end educational and job discrimination against women.

Large numbers of women entered law, medicine, politics, business, and other traditionally male fields. Feminists worked for wider availability of birth control information and legalized abortion in some countries. They also called for men and women to share child care and other family responsibilities.

See also **Women's movement**.

Femur. See **Leg**.

Fencing is the art and sport of swordsmanship using blunted weapons. Fencers use one of three types of weapons—the foil, the epee, or the sabre. Fencing sessions are conducted as individual or team events, though even in team events, only two fencers compete against each other at any one time.

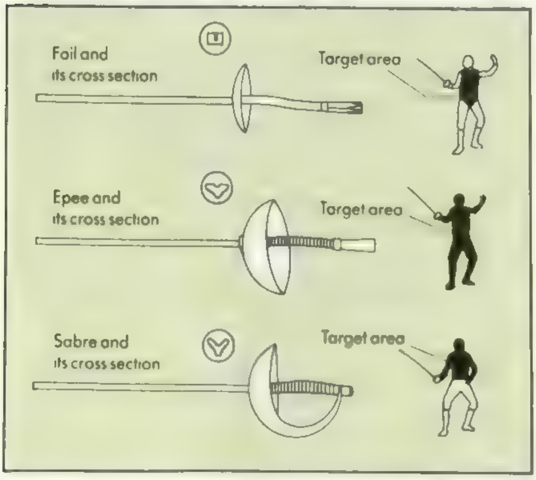
Fencing is the only combative sport open to both men and women. But men and women do not compete against each other. Men's competition may include any one of the three weapons. Women use either the foil or the epee.

There is evidence that fencing competitions date back at least 5,000 years to ancient Egypt and Japan. In Europe, modern swordsmanship dates back to about 1400. Fencing schools became popular in Italy and travelling Italian fencing masters spread the technique of swordsmanship to England, France, and Spain. By the late 1800's, fencing had become part of the education of a gentleman. Fencing was one of the original sports included in the modern Olympic Games.

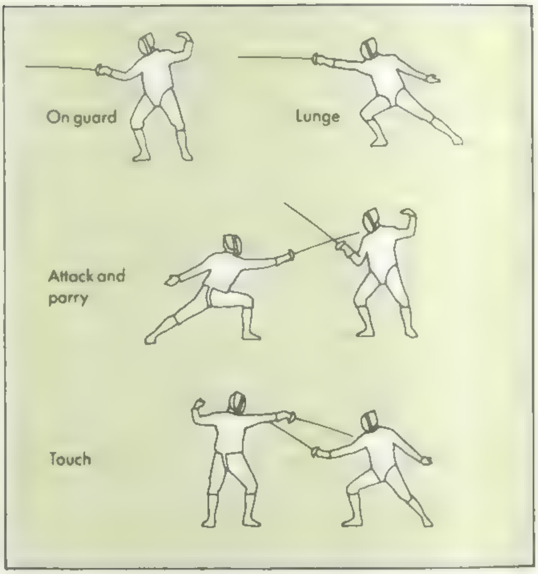
To prevent injuries, fencers wear heavy wire-mesh masks with thick canvas bibs to protect the head and neck. They also wear thick canvas or nylon jackets and knickers and a padded glove on the hand holding the weapon.

The foil has a slender, flexible quadrilateral blade and a small, circular guard. The blade is 90 centimetres long. Foil fencers try to score touches or hits by touching their opponent's torso with the point of the foil.

Foil fencers must follow a certain sequence of moves, called *conventions*. The fencer who first *attacks* has the *right of way* or *priority* in scoring until the defender *parries* (blocks) the attack. The defender is then allowed to *riposte* (counterattack) and holds the right of way until parried. This alternation of action continues until a fencer scores a touch or the action becomes too confused for the chief official, the president, to follow.



Fencing weapons and their target areas



Fencing moves follow a sequence. Competition begins with fencers *on guard*. One fencer uses a *lunge* to *attack*. The defender blocks the attack with a *parry*. A *touch* ends the action.

If a fencer touches the opponent outside the target area, no touch is scored and action resumes. If a fencer touches the opponent on the torso, then a touch is scored. If both fencers touch each other and the president cannot determine who had the right of way, there is no score. Most foil bouts have a 6-minute time limit. The first fencer to score five touches wins.

The epee has a rigid triangular blade with a bell-shaped guard. The blade is 90 centimetres long. Epee fencing has no conventions of right of way. Touches on any part of the body count. However, touches must be scored with the point of the weapon. If both fencers touch each other at the same time, both touches count. Most epee bouts have a 6-minute time limit. Five touches win the bout. Epee fencing for one touch is part of a five-sport competition called the modern pentathlon (see **Pentathlon**).

The sabre has a flexible triangular blade with a guard that curves around the knuckles. The blade is 88 centimetres long. In sabre fencing, touches may be scored on any part of the body above the hips, including the head and arms, either with the point or with one of the two cutting edges. Sabre fencing follows the same conventions of right of way as foil fencing. Most sabre bouts have a 6-minute time limit. Five touches win the bout.

Fencing organizations. Amateur fencing associations were founded in Britain and France in the early 1900's. The International Fencing Federation (FIE) was founded in 1913. The FIE conducts the world championships and the fencing events of the Olympic Games. It also establishes the official rules of the sport.

See also **Olympic Games** (table: Fencing); **Sword**.

The fencing area has a fixed width, but its length depends on the weapon used in the bout. An electronic device activates a light when a fencer scores a touch. A scorekeeper, timekeeper, and signalling apparatus operator sit at a table. The chief official, called the *president,* stands while observing the action.

Fenech, Jeffrey (1964-), became the first Australian boxer to win three world titles. In 1985, he won the International Boxing Federation world bantamweight title. In 1987, he won the World Boxing Council super bantamweight title. In 1988, Fenech won the World Boxing Council featherweight championship.

Fenech was born in the Sydney suburb of Marrickville. He represented Australia at the 1984 Olympic Games but did not win a medal. In 1986, Fenech knocked out Steve McCrory, the American who had won the gold medal in the flyweight class at the Olympics.

Fenech Adami, Eddie (1934-), a leader of the Maltese Nationalist Party, became prime minister of Malta after his party won the general election of 1987. The Nationalists advocated democracy and unity with Europe.

Edward Fenech Adami was born in Birkirkara, Malta. He practised as a lawyer before entering politics. He was leader of the opposition from 1977 to 1987.

Fénelon, François de Salignac de la Mothe- (1651-1715), was a French author and a Roman Catholic archbishop, known for his advanced political, social, and educational ideas. Fénelon's *Treatise on the Education of Girls* (1687) shows his keen understanding of child psychology. His best-known work is *Telemachus* (1699), a novel written to instruct the Duke of Burgundy, grandson of King Louis XIV. The book is about a young man who observes the governments of many countries. It was intended to teach the duke the duties of high office. Fénelon's criticism of absolute monarchy was implied in *Telemachus* and clearly stated in a *Letter to Louis XIV,* published after Fénelon's death. The main idea described in *Telemachus* had been foreshadowed by his *Dialogs of the Dead* (1692). In *Maxims of the Saints* (1697), Fénelon favoured *quietism,* a religious movement that denied the value of conventional religious practices. The church condemned the *Maxims,* and Fénelon lost his influence in religious and court life.

Fénelon was born in Périgord, France. He was ordained in about 1675 and was appointed archbishop of Cambrai, France, in 1695.

Fenian movement was a struggle by Irish nationalists to free Ireland from English rule. In the late 1850's, Irish patriots called *Fenians* began to plan a revolution to achieve independence. The Fenians took their name from the *Fianna,* a band of mythical Irish warriors (see **Irish literature** [Heroic tales, romances, and sagas]).

Most Fenians belonged to a secret society called the Irish Republican Brotherhood (IRB), which was founded in the United States in 1858. In 1866 and 1867, the Fenians attacked police stations in Ireland and set off bombs in England. But the English authorities put down the rebellion and imprisoned hundreds of suspected rebels.

Many people who had emigrated from Ireland to the United States supported the Fenian movement. In the late 1860's, Irish-American Fenians staged three unsuccessful raids on Canada, then a member of the British Empire. The Fenians hoped to take over Canada and hold it as a "hostage" to force England to grant Ireland independence. The Fenian goal of independence through revolution was adopted by later Irish republican movements. In 1921, 26 counties were constituted as the Irish Free State and given the status of a *dominion* (self-governing body) of the British Empire. This followed several years of guerrilla warfare.

See also **Ireland, History of.**

Fenland (pop. 72,900) is a local government district in Cambridgeshire, England. Bordered by The Wash, it forms part of the Isle of Ely and contains the port of Wisbech and the towns of March, Chatteris, and Whittlesey.

Fenland's economy is dominated by agriculture. Its peat and silt soil is among the most fertile in Britain, and the area has large commercial farms. But there is also some light industry. Wisbech is a port handling sugar, petroleum, and other cargoes.

See also **Cambridgeshire.**

Fennec is a small fox that lives in the deserts of North Africa and Arabia. Fennecs rest in burrows during the

The fennec is a small fox with large ears and a black-tipped tail. The animal rests in a burrow during the day and hunts food at night. Fennecs live in North Africa and Arabia.

day. At night, they seek such food as birds and birds' eggs, insects, lizards, rodents, and various bulbs and fruits. Fennecs have pale reddish-orange, sandy, or white fur. The tail has a black tip. A fennec weighs about 1.5 kilograms. Its exceptionally large ears may grow as long as 15 centimetres. Fennecs live in family groups with two to five young.

Scientific classification. The fennec belongs to the dog family, Canidae. It is *Fennecus zerda.*

See also **Fox** (Fennecs).

Fennel is a herb related to parsley. It grows wild as a perennial plant in southern Europe, but is cultivated in other parts of the world.

The fennel plant has fragrant, finely divided leaves and yellow flowers. Its seeds also are fragrant, and they have a liquorice taste. The leaves and seeds are used to flavour sweets, liqueurs, medicines, and fish and other foods. Oil of fennel, which is made from the seeds, is used in giving soaps and perfumes a pleasing fragrance. In Italy, young shoots of one variety of fennel are served as a vegetable.

Fennel

A group of plants called *fennelflowers* are related to buttercups but not to fennel. Fennelflowers grow in western Asia and in the region of the Mediterranean Sea. One variety of fennelflower has black and brown seeds that are used as seasoning for breads and pastries.

Scientific classification. Fennel is a member of the parsley family, Umbelliferae (Apiaceae). It is *Foeniculum vulgare.* Fennelflower belongs to the buttercup family, Ranunculaceae. It is *Nigella hispanica.*

Fens are a low-lying region of land in England, extending west and south of The Wash as far as Cambridge. They include parts of Lincolnshire, Norfolk, Cambridgeshire, and Suffolk. The Fens (also called the *Fen Country*) form the drainage basin of the rivers Great Ouse, Nene, Welland, and Witham. They cover about 2,000 square kilometres (200,000 hectares).

The Romans tried to drain the Fens, which are naturally marshy. Cornelius Vermuyden, a Dutch engineer, first drained part of the area in the 1620's. The fifth Earl of Bedford continued the reclamation work. The *Bedford Level,* the southern part of the Fens, is named after him. The region west of King's Lynn, the *Marshland,* has fine medieval churches.

Fer-de-lance is one of the largest and deadliest of the poisonous snakes. It lives in tropical North and South America. It has velvety scales, marks of rich brown and grey, and a yellowish throat. The fer-de-lance lives in both wet and dry places, in forests as well as open country. It eats birds and small animals. There may be over 60 young snakes in one brood. The baby snakes are about 30 centimetres long. They have fully formed fangs at birth, and can give a poisonous bite. A fer-de-lance strikes swiftly. The snake may grow to be 2.5 metres long. Its name is French and means *lance head.*

The fer-de-lance is a large, poisonous snake that lives in tropical regions of North and South America.

Scientific classification. The fer-de-lance belongs to the viper family, Viperidae. It is *Bothrops atrox.*

See also **Viper.**

Ferber, Edna (1885-1968), an American novelist and playwright, wrote many books about the colourful life of America in the 1800's. She won the 1925 Pulitzer Prize for fiction for her first best-selling novel, *So Big* (1924).

Ferber also wrote *Show Boat* (1926), *Cimarron* (1930), *Saratoga Trunk* (1941), *Giant* (1952), and *Ice Palace* (1958). *Show Boat* was made into a popular musical comedy, and all of these books became successful films. She said that she intended her books to be social criticism as well as good stories. She often wrote about strong women characters. Ferber's other novels include *Dawn O'Hara* (1911), her first book; *The Girls* (1921); and *Come and Get It* (1935). *Roast Beef, Medium* (1913) is a collection of stories. She had considerable success with the plays she wrote with George S. Kaufman. The best known of these plays are *The Royal Family* (1927), *Dinner at Eight* (1932), and *Stage Door* (1936).

Edna Ferber

Ferber was born in Kalamazoo, Michigan, U.S.A., but she grew up in Appleton, Wisconsin. Her first ambition was to become an actress. However, at the age of 17, when her father went blind, she took a newspaper job with the *Appleton Daily Crescent.* Ferber told her life story in two books, *A Peculiar Treasure* (1939) and *A Kind of Magic* (1963).

Ferdinand II (1578-1637) ruled the Holy Roman Empire from 1619 until his death. A devout Roman Catholic, Ferdinand dedicated his reign to restoring Catholicism to its former dominant position in the Protestant German states of the empire.

Ferdinand was the son of Archduke Charles of Styria, a province in what is now Austria. Ferdinand belonged

to the Habsburg (or Hapsburg) family, which had long controlled the empire. He became emperor during the Thirty Years' War (1618-1648). The war had begun as a conflict between Protestants and Catholics, and Ferdinand defeated many rebel Protestant nobles.

To limit Ferdinand's power, leaders from several European countries began to help the rebels. Catholic nobles in the empire also grew to fear Ferdinand's power. In 1635, Ferdinand forced both Catholic and Protestant nobles to sign the Peace of Prague, increasing his authority over them. But expansion of the war quickly ended his dominance.

See also Thirty Years' **War**.

Ferdinand III (1608-1657) ruled the Holy Roman Empire from 1637 until his death. He tried to promote his authority over the German states of the empire and strengthen the Roman Catholic Church in those states. He led the Catholic delegation that signed the peace treaty ending the Thirty Years' War (1618-1648).

Ferdinand was a member of the House of Habsburg (or Hapsburg), a Catholic family that had long dominated the empire. He succeeded his father, Ferdinand II, as emperor and continued his father's policies in the Thirty Years' War. During this war, Ferdinand III sought to increase his authority over the German states, promote Catholicism in Germany, and expand Habsburg power in Europe. But the war exhausted his resources. Following several military defeats, he signed the Peace of Westphalia in 1648. This agreement ended the war. It weakened Ferdinand's authority in the empire, but strengthened his control over the Habsburg family's lands.

Ferdinand V (1452-1516), king of Castile and Aragon, married his cousin, Isabella I, in 1469. This marriage led to the unification of Castile and Aragon, Spain's two largest kingdoms (see **Isabella I**). The two rulers increased Spain's power by conquering the Moors, a largely Arabic civilization of the Middle Ages (see **Moors**), in 10 years of war and by sending Christopher Columbus to America. After Isabella's death in 1504, Ferdinand added Naples and the province of Navarre to his kingdom. He was also known as Ferdinand II of Aragon and Sicily, and as Ferdinand III of Naples. He was born in Sos, Aragon. See also **Castile and Aragon; Columbus, Christopher** (Success in Spain); **Spain** (Union of the Spanish Kingdoms).

Ferdinand, Archduke. See **World War I** (The assassination of an archduke).

Ferguson, Harry (1884-1960), was an Irish engineer and inventor. He developed one of the first successful farm tractors and later went into partnership with the American businessman Henry Ford.

Henry George Ferguson was born in Dromore, County Down. He left school at 16 and started a garage in Belfast. In 1909, he designed and built a monoplane, in which he became the first person in Ireland to fly. In 1920, he devised a revolutionary new tractor, with mounted ploughs which were integrally linked. The Ferguson-Sherman Company was formed in the United States in 1922, and thousands of tractors were sold. He later developed a system of hydraulic control. In 1954, he sold out and retired from his company.

Fergusson, Robert. See **Scottish literature** (1700-1800).

Enniskillen, the main town in Fermanagh, is on an island in the River Erne, between Upper and Lower Lough Erne.

Fermanagh is the most westerly of the six counties of Northern Ireland. It comprises the basin of the River Erne and the land on either side of the two large lakes, Upper Lough Erne and Lower Lough Erne. The River Erne rises in the Republic of Ireland and crosses the southern boundary of the county of Fermanagh to form Upper Lough Erne. The lough then narrows and forms two channels on either side of the town of Enniskillen. These channels join up again and broaden out into Lower Lough Erne. From this imposing lough the river reemerges and flows through County Donegal in the Republic of Ireland to the Atlantic Ocean.

Fermanagh was abolished as an administrative county in 1973. Since then, the central part of County Fermanagh has been known officially as the administrative district of Fermanagh. This administrative area is bounded by the districts of Dungannon and Omagh to the northeast and by the Republic of Ireland to the south.

The old county had the smallest population of any county in Northern Ireland. At the 1991 census, it had a population of 54,290. The government no longer collects figures for the population living within the old county borders. The county covered 18,509 square kilometres. The new district is 851 square kilometres.

The whole county of Fermanagh is an area of outstanding natural beauty. Upper Lough Erne has many

Fermanagh is the most westerly county of Northern Ireland. The Republic of Ireland borders the county on three sides.

wooded islands and winding channels. But the soil is unsuitable for farming, because it is water-logged in the lowlands and infertile in the mountains.

There are few high mountains. Cuilcagh on the border with County Cavan rises to 668 metres. Much of the Erne basin is formed from limestone, honeycombed in some places by caves and deep potholes hollowed out by underground streams. There is an extensive series of caves at Marble Arch, near Florencecourt. The arch is really the mouth of an underground river that flows through the caves for a considerable distance before reappearing above ground.

Economy. Little of the land in County Fermanagh is cultivated. But farmers do rear cattle, sheep, and pigs. Farm products include meat, milk, and cheese.

Food processing is the largest local industry. Other industries are light engineering, the manufacture of knitwear and clothing, and the production of plastic goods. A famous, fine porcelain is produced at the village of Belleek on the border, the most westerly point in Northern Ireland.

Tourism is a major industry in County Fermanagh, which is one of Northern Ireland's most popular holiday areas. Tourists are attracted by its magnificent scenery, its fishing, its water sports, and its caves. Tourism is a major employer of labour in the county.

Chief towns. Enniskillen, the former county town and now the seat of the administrative district of Fermanagh, is the main centre. Located strategically between Upper and Lower Lough Erne, it has had a stormy history as a fortified town on the edge of the Ulster Plantation (see **Northern Ireland** [History]). Enniskillen has many historic monuments including its castle and the Water Gate. Portora Royal School, founded by King Charles I, numbers among its many famous former pupils the writer Oscar Wilde. Other small market towns in Fermanagh are Irvinestown, Lisnaskea, Ballinamallard, Kesh, Brookborough, Lisbellaw, Florencecourt, and Newtownbutler.

History. The islands of Lower Lough Erne are particularly rich in prehistoric and early Christian monuments. The island of Devenish has a fine round tower and the ruins of several churches. Interesting Celtic carving and figures are located on Devenish and on other islands.

The military importance of County Fermanagh on the western flank of the English and Scottish settlements in Ulster in the 1600's is evident from the presence in the county of settlers' castles and fortified houses. Fermanagh was specially important at the end of the 1600's during the war between the forces of James II and William III. Protestants from Enniskillen defeated the army of James II at Newtownbutler in 1689.

During the 1800's and 1900's, people left the county because of its remoteness and its poor soils. The population fell by two-thirds between the Irish famine of the 1840's and the 1980's.

The war memorial in Enniskillen was the scene of one of the worst atrocities of the Ulster troubles, when an Irish Republican Army bomb killed and injured many people at a Remembrance Day service in 1987.

Fermat, Pierre de (1601-1665), a French mathematician, won fame for his work on the theory of numbers or integers. He also contributed to the invention of analytical geometry and calculus. He formulated the least-time law to explain the *refraction* (bending) of light, and also developed an equation for the graph of a straight line. Fermat and Blaise Pascal are credited with originating the theory of probability (see **Probability**).

Fermat's famous "last theorem" concerns the equation $x^2+y^2=z^2$. Fermat knew that the equation could be correct if whole numbers were substituted for the letters x, y, and z (for example, $3^2+4^2=5^2$). His theorem states that there is no solution in integers to $x^n+y^n=z^n$ if the exponent, n, is larger than 2. For over 350 years, the theorem was neither proved nor disproved. In 1993, British mathematician Andrew Wiles seemed to have provided convincing proof of Fermat's theorem. Experts since, however, have shown his work to be incomplete.

Fermat practised law in Toulouse, France, and studied mathematics only as a hobby. He was born in Beaumont-de-Lomagne, France.

Fermentation is a chemical process that breaks down organic materials. This process is carried out by such microbes as bacteria, moulds, and yeasts. For example, moulds or fungi act upon mixtures of molasses and mineral salts to produce penicillin. Yeast breaks down sugar obtained from malted grain into ethyl alcohol and carbon dioxide gas for use in beer. Sugar from grape juice is broken down in the same way for use in wine. Fermentation is also essential in the production of bread, cheese, and yoghurt. But fermentation can be unhealthy. For example, fermented milk turns sour.

Fermented products useful to human beings are manufactured in large quantities. Although a variety of substances are produced by fermentation, the basic processes are similar. First, large stainless steel tanks are filled with a watery solution of nutrients. This solution is sterilized with steam to kill unwanted germs. Certain microbes are then added to the solution, and they ferment the nutrients over a period of several days. Workers carefully control the temperature and acid quality of the material in the tanks. Finally, the tanks are drained, and the desired product is separated from the rest of the mixture by extraction, filtration, or some other means. In most cases, this product makes up only about 5 per cent of the mixture in the tanks, so purification is often extremely complicated.

Fermentation has been used to make alcoholic beverages since ancient times. People who lived along the Nile River in northeast Africa brewed beer around 3000 B.C. It was not until the A.D. 1800's, however, that scientists—particularly the French scientist Louis Pasteur—discovered how microbes cause fermentation in beer, milk, and wine.

In the 1900's, other types of fermentation were developed. Fermentation of a bacterium produced ingredients for explosives during World War I (1914-1918). Since 1943, the most important application of fermentation has been in the production of *antibiotics* (disease-killing drugs), especially penicillin. Fermentation is also used in certain other drugs, in vitamins, and in some types of chemicals.

See also **Alcoholic beverage; Brewing** (picture: Fermentation); **Enzyme; Pasteur, Louis; Wine** (How wine is made).

Fermi, Enrico (1901-1954), an Italian-born American physicist, designed the first atomic pile and produced the first nuclear chain reaction in 1942. He later worked on the atomic bomb project at Los Alamos, New Mex-

ico, U.S.A. Fermi won the 1938 Nobel Prize for physics for his work on nuclear processes. He also made important contributions to quantum theory and other areas of physics.

Enrico Fermi

Fermi began bombarding many elements with neutrons in 1934. He proved that slow neutrons are very effective in producing radioactive atoms. This discovery was particularly important, because slow neutrons can split U-235. As a result of these experiments, Fermi announced in 1934 what he thought were elements lying beyond uranium, not realizing that he had actually split the atom. Otto Hahn and Fritz Strassmann of Germany performed a similar experiment in 1938. Lise Meitner and Otto Frisch showed that the uranium atom had been split, and named the process *nuclear fission* (see **Meitner, Lise**).

Fermi was born in Rome. He received a doctor's degree from the University of Pisa in 1922. He then returned to Rome, where he became professor of theoretical physics at the University of Rome in 1927. Fermi left Italy in 1938 to escape the Fascist regime, and settled in the United States. He became a professor of physics at Columbia University, in New York City, in 1939. He moved to the University of Chicago as a professor of physics in 1942. Fermi led the work on the first nuclear chain reaction. He became an American citizen in 1944. After World War II, he pioneered in research on high-energy particles.

See also **Nuclear energy** (Development).

Fermium is an artificially created radioactive element. Its atomic number is 100, and its chemical symbol is Fm. Fermium has 18 known isotopes. Its most stable isotope has a mass number of 257 and a half-life of 100 days (see **Radioactivity** [Half-life]). A team of American scientists led by Albert Ghiorso discovered fermium in 1953. They found it in radioactive debris produced by the first hydrogen bomb explosion in 1952. Fermium was named after Enrico Fermi, the Italian nuclear physicist who produced the first controlled nuclear chain reaction (see **Fermi, Enrico**).

Extremely small amounts of fermium are produced in nuclear reactors for scientific research. Chemical compounds of fermium have not been produced in weighable amounts. Therefore, its chemical properties are not completely known to scientists.

See also **Einsteinium; Element, Chemical; Radioactivity; Transuranium element.**

Fern is a green, nonflowering plant that grows in most parts of the world. Ferns differ widely in size and form. Some ferns look like mosses and measure about 2.5 centimetres in length. Others resemble palm trees and grow more than 20 metres tall. Ferns have some of the most beautiful and varied leaves in the plant world. The leaves of many ferns are long and lacy and consist of hundreds of tiny leaflets. Other ferns have simple, rounded leaves.

Ferns can be found in all parts of the world except the driest deserts and coldest regions. There are approximately 10,000 species of ferns worldwide. Most ferns grow in damp, shady areas. The best places to look for ferns are along streams in woods and in the cracks and overhangs of rock cliffs. In tropical regions, ferns are common on the trunks and branches of trees.

Ferns are among the oldest kinds of plants that live on land. Scientists believe that ferns appeared on earth more than 350 million years ago. Like mosses and other nonflowering plants, ferns reproduce by means of microscopic cells called *spores*. Most ferns produce spores on the underside of their leaves.

People enjoy ferns mainly for their beauty. Ferns are grown in many gardens, especially as a background in shady areas. Several ferns are popular as house plants.

Parts of a fern. Ferns have well-developed stems, roots, and leaves. The stem of a fern stores food which the plant needs to grow. As long as the stem is alive, the fern will continue to grow and make new leaves and roots. The stem may grow upright above the ground, horizontally along the ground, or even underground. A stem that grows along the ground or underground is called a *rhizome*. The stems of ferns often form branches. A large clump of ferns forms if a stem branches many times. Fern stems usually grow slowly and may live for 100 years or more.

The roots also may live a long time. They anchor the stem to the ground and absorb water and nutrients.

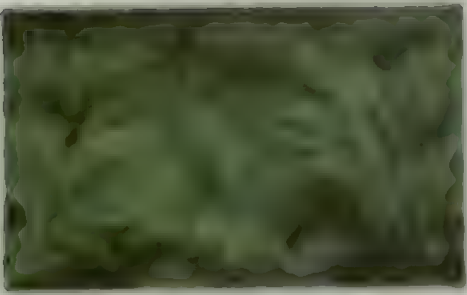
Unlike the stem and roots, the leaves of a fern usually live only one or two years. A new set of leaves grows from the tip of the stem every year. A young fern leaf is coiled like the top of a violin. It uncurls as it grows. The leaf is attached to the stem by a stalk called the *stipe*. The fern leaf is often called a *frond*.

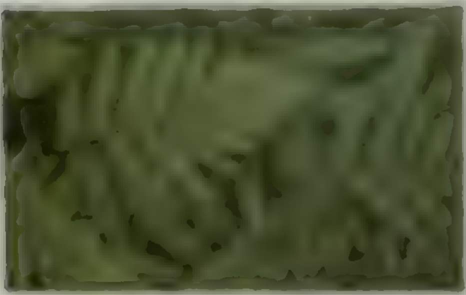
Fern leaves make food for the plant by a process called *photosynthesis* (see **Photosynthesis**). Many fern leaves also carry the tiny structures that produce spores. These structures, called *sporangia*, have a stalk and a capsule filled with spores. Usually, sporangia are found in clusters on the underside of fern leaves. Each cluster of sporangia is called a *sorus*, and all the clusters on a fern are the *sori*. Ferns are the only plants that have sori and so they are easy to identify.

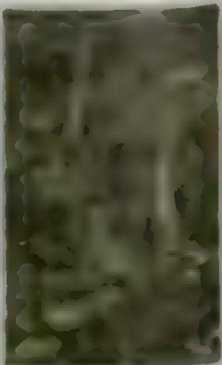
Life cycle of a fern. Ferns grow and reproduce in two stages—*sexual* and *asexual*. This kind of life cycle, called *alternation of generations*, involves two distinct forms of the fern plant.

During the asexual stage, the fern plant is called a *sporophyte*. The sporophyte produces leaves with sporangia and is the plant commonly recognized as the fern. After the sporangia mature, they split open in dry air and release their spores. A sporophyte may produce millions of spores. But only some of the spores land in places suitable for growth. Most fern spores grow best in shaded, moist soil. A fern spore develops into a tiny, heart-shaped plant that is called a *gametophyte*.

The growth of the gametophyte begins the sexual stage of the fern's life cycle. The gametophyte of a fern is usually called a *prothallium*. After a few weeks, the prothallium develops organs that produce male and female sex cells, called *gametes*. The male sex organ, called the *antheridium*, produces sperm. The female sex organ, the *archegonium*, contains an egg. In most ferns, both antheridia and archegonia are produced on the







Ferrier, Kathleen (1912-1953), was an English contralto who sang opera, oratorio, and *lieder* (German art songs) with equal distinction. The tone of her voice was extremely rich and mellow, and she sang with superbly restrained artistry. She sang the title role in the première of Benjamin Britten's opera *The Rape of Lucretia* in 1946, and later distinguished herself in the title role of Gluck's *Orfeo.* Musicians greatly admired her singing of Mahler's symphonic song cycle *The Song of the Earth* and Brahms's *Four Serious Songs.* She sang throughout Europe and the United States. Kathleen Ferrier was born at Higher Walton, in Lancashire, England.

Ferris wheel is an entertainment device used at fairs, carnivals, and amusement and theme parks. A Ferris wheel is a power-driven vertical wheel with a steel frame. Passenger cabs are mounted on the rim of the wheel. Present-day Ferris wheels stand about 12 to 14 metres high and carry from 12 to 16 passenger cabs.

Ferris wheels were originally called *pleasure wheels.* The largest wheel was built by George W. Gale Ferris, a mechanical engineer in Galesburg, Illinois, U.S.A. Ferris built it for the World's Columbian Exposition in Chicago in 1893. The wheel was 76 metres in diameter. Each of its 36 cabs could hold 60 people. This Ferris wheel was used at the Louisiana Purchase Exposition in St. Louis, Missouri, U.S.A. in 1904 and then sold for scrap metal.

In 1900, William E. Sullivan began making portable versions of the Ferris wheel in Jacksonville, Illinois, U.S.A., for the Eli Bridge Co. In England, a Ferris wheel is sometimes called an *Eli wheel* or a *big wheel.*

Ferrous sulphate (chemical formula, $FeSO_4 \cdot 7H_2O$), is a substance that occurs in light-green crystals. The crystals turn rusty brown when they react with oxygen in moist air. Ferrous sulphate is an iron salt of sulphuric acid. It can be made by combining iron with sulphuric acid or by oxidizing *iron pyrites,* a compound of iron and sulphur. Ferrous sulphate is used to dye fabrics and leather, and to make ink. It is also used to purify water, and as a disinfectant, wood preservative, and weed killer.

The Ferris wheel at the World's Columbian Exposition in Chicago in 1893 was the largest ever built. Its 36 passenger cabs could carry 2,160 people.

A ferry can carry people, vehicles, and freight across rivers, lakes, bays, and other bodies of water.

Ferry is a boat used to carry persons, vehicles, and freight across narrow bodies of water. Most ferries have a large opening at each end so they can be loaded and unloaded without being turned around.

People have used ferries for thousands of years. Early ferries included rafts and small boats that were rowed, sailed, or moved by poles across the water. Many ferries were guided by cables stretched between the shores, and were pulled by ferry workers on the shore of destination. Some cable-guided ferries are pushed by motorboats. Most large ferries in use today are powered by their own engines.

Bridges and tunnels have replaced many ferries.

See also **Ship** (Other passenger vessels).

Fertile Crescent was a crescent-shaped region in southwest Asia. This historic region began at the Mediterranean Sea, stretched between the Tigris and Euphrates rivers, and ended at the Persian Gulf. In this area, the

The Fertile Crescent was a historic region that curved around the Syrian Desert in southwest Asia. The Sumerians developed the world's first civilization there about 5,500 years ago. Other advanced ancient cultures also developed in the region.

Sumerians developed the world's first civilization about 5,500 years ago. James H. Breasted, an American archaeologist, named the region the *fertile crescent* because these people and their successors created rich, irrigated farmlands. The Assyrians, Babylonians, Eblaites, Hebrews, Mitannians, and Phoenicians also lived and ruled in the Fertile Crescent.

See also **Asia** (History); **Syria** (introduction).

Fertility drug. See **Fertilization; Multiple birth.**

Fertilization is the process by which male and female sex cells unite to form a new individual. It is the first step in sexual reproduction. The male reproductive system produces sex cells called *spermatozoa,* or *sperm.* The female reproductive system produces sex cells called *eggs.* A fertilized egg, which results from the union of a sperm and an egg, is called a *zygote.* As the zygote develops further, it becomes an *embryo.* This article discusses fertilization among animals. For information about fertilization among plants, see **Plant** (How plants reproduce).

Among animals, fertilization may be external or internal. During external fertilization, male and female sex cells unite outside the female's body. This process occurs in water. The male releases sperm into the water at about the same time that the female releases eggs. Some sperm come into contact with eggs and fertilize them. Almost all aquatic invertebrates and some vertebrates, including the majority of fish and amphibians, reproduce in this way.

Internal fertilization occurs when the male deposits sperm directly into the female's body. Most land animals, including insects, reptiles, birds, and mammals, reproduce in this way. In almost all mammals and some reptiles, the embryo develops inside the female's body after fertilization. However, in birds and many reptiles, the embryo develops outside her body. The female lays an egg in which the embryo develops. The egg is protected by a shell and contains material that nourishes the growing embryo.

Scientists have developed methods of promoting fertilization in mammals, including human beings. For example, *fertility drugs* increase a female's chances of becoming pregnant. In addition, eggs may be fertilized by a process called *artificial insemination.* In this process, sperm are collected from the male and later injected into the female by artificial methods.

Scientists have also united mammalian sperm and eggs *in vitro*—that is, in an artificial environment outside the female's body. The zygote must then be transferred into the female reproductive system to develop further. The few human infants that have resulted from in vitro fertilization are sometimes called "test-tube babies."

See also **Breeding; Embryo** (Fertilization); **Infertility; Pollen; Reproduction.**

Fertilizer is a substance that is added to soil to help plants grow. Farmers use various kinds of fertilizers to produce abundant crops. Home gardeners use fertilizers to raise large, healthy flowers and vegetables. Landscapers spread fertilizers on lawns and golf courses to help grow thick, green grass.

Fertilizers contain *nutrients* (nourishing substances) that are essential for plant growth. Some fertilizers are made from organic waste, such as manure or sewage. Others are manufactured from certain minerals or from synthetic compounds produced in factories.

People have used fertilizer for thousands of years—even though at one time they did not know why it was beneficial for plants. Long before they gained an understanding of plant nutrition, people noticed that animal droppings, wood ashes, and certain minerals helped plants thrive. During the 1800's and early 1900's, scientists discovered that certain chemical elements were essential for plant nutrition.

Today, farmers worldwide use huge quantities of fertilizer each year. Increased production resulting from the use of fertilizer probably accounts for about a fourth of the world's total crop production. Without fertilizer, greater amounts of land and labour would be needed to produce the same quantities of crops.

The importance of fertilizer

Green plants produce the food they use. They produce it by means of the process of photosynthesis (see **Photosynthesis**). This process requires large amounts of nine chemical elements—carbon, hydrogen, oxygen, phosphorus, potassium, nitrogen, sulphur, calcium, and magnesium. It also requires smaller amounts of several other elements. These elements, called *micronutrients* because so little of each is needed, include boron, copper, iron, manganese, molybdenum, and zinc.

Air and water provide most of the carbon, hydrogen, and oxygen that green plants need for growth. The other elements must come chiefly from the soil.

The elements plants receive from soil are normally provided by decaying plant and animal matter and dissolved minerals. But sometimes the soil does not have enough of these substances, resulting in a need for fertilizer. The harvesting of crops, for example, involves removing plants from the soil before they die and decay. The soil does not receive the mineral elements contained in the crops, and so fertilizer must be added to supply them. Nitrogen, phosphorus, and potassium are the elements in which soil is most frequently deficient.

Kinds of fertilizers

There are two principal kinds of fertilizers, *mineral* and *organic.* Manufacturers produce mineral fertilizers from certain minerals or synthetic substances. Organic fertilizers come from decayed plant or animal matter.

Mineral fertilizers are the most widely used fertilizers. They supply three main elements: (1) nitrogen, (2) phosphorus, and (3) potassium.

Nitrogen fertilizers, the most widely used mineral fertilizers, are produced mainly from ammonia gas. Manufacturers use ammonia in making such liquid fertilizers as anhydrous ammonia and aqua ammonia. They also use it in producing solid fertilizers, such as ammonium sulphate, ammonium nitrate, ammonium phosphate, and an organic compound called *urea.* Each of these fertilizers provides the soil with large amounts of nitrogen. Some, including ammonium sulphate and ammonium phosphate, furnish other elements as well as nitrogen.

Phosphorus fertilizers, also called *phosphates,* are made from the mineral apatite. Finely ground apatite may be applied to soil as a solid fertilizer called *rock phosphate.* Apatite also may be treated with sulphuric acid or phosphoric acid to make liquid fertilizers called *superphosphates.*

Potassium fertilizers come largely from deposits of potassium chloride. Manufacturers mine the deposits or extract them with water to produce potassium chloride, potassium nitrate, and potassium sulphate.

Other mineral fertilizers provide soil with various elements. Those made from gypsum, for example, supply sulphur. Manufacturers also produce fertilizers that provide specific micronutrients.

Organic fertilizers are made from a variety of substances, including manure, plant matter, sewage water, and packing house wastes. These fertilizers contain a smaller percentage of nutrients than do mineral fertilizers. Therefore, they must be used in larger quantities to obtain the same results. Some organic fertilizers may also cost more. But they solve a disposal problem because organic waste has few uses other than as fertilizer. Plant matter is used as fertilizer in two main ways, (1) as a compost heap or (2) as green manure.

A compost heap consists of alternate layers of plant matter and soil. Fertilizer mixed with lime is also usually added. The heap is allowed to decay for several months before being used as fertilizer. See **Compost**.

Green manure consists of certain crops that farmers use as fertilizer. For example, some plants have bacteria in *nodules* (knotlike growths) on their roots. These bacteria take nitrogen out of the air. Such plants, called *legumes,* include alfalfa, beans, and clover. Farmers may plant a crop of legumes and then plough the young plants into the soil. As the plants decay, nitrogen returns to the soil and enriches it so it can nourish other crops.

The fertilizer industry

About 95 per cent of the fertilizer produced in the world is used on farm crops. The United States is one of the world's leading producers of fertilizer. Other leading producers include Canada, China, France, and India.

Raw materials for fertilizer come from several sources. Ammonia, the basic source of nitrogen fertilizer, is formed by combining nitrogen from the air with hydrogen from natural gas. Several oil firms in the United States produce ammonia because they have supplies of natural gas.

The world's leading producers of phosphate rock are the United States, Russia, and Morocco. Morocco has the largest reserves of phosphate rock.

The largest deposits of potassium chloride, the major source of the various kinds of potassium fertilizer, occur in Canada.

Production and sale. Fertilizer is produced in four basic forms. It can be produced as *straight goods,* as a *bulk blend,* as a *manufactured fertilizer,* or as a *liquid.* Straight goods fertilizer is any chemical compound that contains one or two fertilizer elements. Bulk blend fertilizer is a mixture of straight goods in certain proportions. Manufactured fertilizer consists of two or more chemicals that are mixed and then formed into small grains. Each grain contains nitrogen, phosphorus, and potassium and perhaps certain micronutrients. Liquid fertilizer consists of one or more fertilizer materials that have been dissolved in water. It may be sprayed onto plants or soil, injected into soil, or added to irrigation water.

Most fertilizers release their plant nutrients into the soil almost immediately. Manufacturers also produce a special type of fertilizer, called *slow-release fertilizer,* that gives up its nutrients gradually. This type has been found useful when plants need a constant supply of nutrients over a long period of time.

Commercial fertilizer containing nitrogen, phosphorus, and potassium helped produce the healthy green maize on the left. The weak, brown maize on the right received no fertilizer

Problems of the fertilizer industry. Every year, millions of metric tons of fertilizer must be produced to meet the world's growing need for food. The fertilizer industry tries to match its production with this need. If the industry does not do so, severe food shortages might result.

A shortage of raw materials could cause a low supply of fertilizer. Some materials, such as natural gas and phosphorus, have uses other than in making fertilizer. Their use by other industries could cause a shortage for fertilizer manufacturers.

The mining and processing of the raw materials needed to make fertilizer may damage the environment. Many minerals used in making fertilizer come from opencast mines, which cause large unproductive and ugly areas unless properly landscaped. In addition, the excessive use of fertilizer can contribute to water pollution. Erosion may carry fertilized soil into lakes and streams. The nutrient elements in the soil then increase the growth of *algae* (simple plantlike organisms) in water. When the algae die, they produce large amounts of waste. As the waste decays, it uses up the oxygen supply of the water, killing fish and other plant life.

Related articles in *World Book* include:

Fertilizer materials

Ammonia	Mulch
Anhydrous ammonia	Nitrate
Ash	Nitrogen
Calcium	Phosphate
Compost	Phosphoric acid
Guano	Phosphorus
Lime	Potassium
Limestone	Sulphur
Manure	Urea
Marl	

Other related articles

Agriculture (New agricultural chemicals)	Eutrophication
Agronomy	Soil (Characteristics of soils)
	Water pollution

Fès. See **Fez** (city).

Fescue is the name of a group of grasses that grow mostly in the temperate regions of the Northern Hemisphere. There are about 300 species. Fescues have fine leaves which roll inward during dry weather. This reduces water loss from the plants, and helps them survive until it rains again.

Sheep's fescue and *red fescue* are common European grasses. They are also grown as lawn grasses. *Chewings's fescue* is a variety of red fescue that is especially popular as a lawn grass.


Fescue grass

Many varieties of fescue, such as those with bluish-grey leaves and purplish *panicles* (flower heads), are cultivated as ornamental plants. They prefer light, well-drained soil. Many species are also used as pasture grasses for feeding livestock. *Meadow fescue* is a common pasture grass.


Fetishes can take the form of such common objects as stones and bones, *above.* These fetishes belong to a Kikuyu witch doctor of Kenya. The Kikuyu believe that spirits control the fetishes and that a witch doctor can predict the future by tossing them.

Scientific classification. Fescues belong to the grass family Graminaeae (Poaceae). Sheep's fescue is *Festuca ovina;* red fescue is *F. rubra;* Chewing's fescue is *F. rubra* var. *commutata;* meadow fescue is *F. pratensis.*

See also **Grass.**

Festival. See **Feasts and festivals.**

Festival of Light. See **Sweden** (Holidays).

Festival of Lights. See **Hanukkah.**

Fetish is an object that supposedly has magic powers. Many peoples worship bones, carved statues, unusual stones, and other objects as fetishes. In some societies, people carry such fetishes as a rabbit's foot or a "lucky" penny to bring them good luck.

Europeans first learned about *fetishism* (the worship of fetishes) when Portuguese explorers colonized Africa during the late 1400's. Many African peoples had fetishes and treated them with great devotion and respect. Fetishism is a type of *animism,* the belief that lifeless things have a spirit (see **Animism**). Fetish worshippers believe that the spirit protects them from evil and brings them good luck. A fetish may become an *idol,* the image of a god, if word of its power spreads beyond the community (see **Idolatry**).

Psychiatrists use the term *fetishist* for a person who has an abnormal sexual attachment for a lifeless object. Such objects may include a lock of hair, a shoe, or a piece of clothing.

See also **Mythology** (African mythology); **Sculpture** (African); **Superstition.**

Fetus. See **Baby** (The developing baby); **Pregnancy** (The baby during pregnancy).

Feud is a long and sometimes murderous conflict between individuals, families, or groups. Feuds often occur in societies that lack a police force, other government law enforcement agency, or other form of central authority. They are also common in regions far from the centre of authority or where central authority is hard to enforce because of rugged terrain or a harsh climate. In addition, people inclined to take the law into their own

hands frequently become involved in feuds. For example, feuds can occur among city youth gangs and underworld organizations.

Most feuds begin when a member of one group or family insults or harms a member of another group or family. Then members of the victim's group seek revenge. If they seek to avenge a murder, they will probably kill the murderer or a member of the murderer's family. One such attack leads to another, and the feud continues. Families may keep fighting for years. Often, no person of either family can remember why the feud began, but new acts of violence keep it alive.

Many feuds have occurred in the mountains of Afghanistan; on the islands of Corsica and Sicily; on the Balkan Peninsula; and among such isolated African herding societies as the Masai and the Nuer. Feuds have also occurred in the Appalachian Mountains of the United States.

Feuds have formed the basis of many works of literature and of drama. One of the most famous of these works is Shakespeare's Romeo and Juliet (see **Shakespeare, William**).

See also **Vendetta**.

Feudalism is the general term used to describe the political and military system of western Europe during the Middle Ages. At that time, there was no strong central government and little security, but feudalism fulfilled the basic need for justice and protection.

Feudalism is often confused with *manorialism*. Manorialism was the system of organizing agricultural labour. It refers to the economic relationship between the lord of a manor and his peasant tenants (see **Manorialism**). Feudalism, on the other hand, was mainly a political and military system. Both the lord and his subjects, called *vassals,* were aristocrats. The lord gave vassals land in return for military and other services. The lord and the vassals were bound through ceremonies and oaths to be faithful to each other and to observe their obligations. The peasants had no part in such arrangements.

The word *feudal* comes from a Latin term for *fief*. The fief was the estate or land granted by a lord in return for a vassal's loyalty and service. Some fiefs were large enough to support only one knight. Others were great provinces of a kingdom, such as the province of Normandy in France. The church, which owned large fiefs, was also part of the feudal system.

Feudalism developed to meet the needs of its time. In the A.D. 400's, Germanic tribes conquered the West Roman Empire and divided it into many kingdoms. The Germanic peoples—called *barbarians* by the Romans—were loyal only to their tribal chiefs or to their families. Thus, the strong central and local governments of the Romans disappeared. In addition, barbarian customs replaced many Roman laws. Such changes and further invasions resulted in general disorder and constant warfare in the years following the barbarian conquest of the West Roman Empire. Feudalism helped establish order in Europe under these conditions.

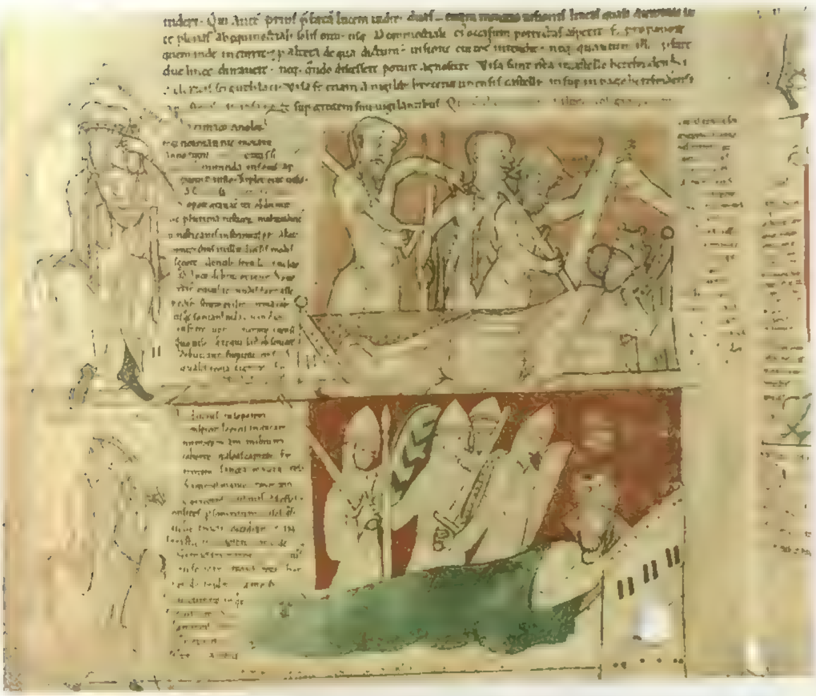
Feudalism began to appear in the 700's. By the 1100's, it had spread from France into England, Spain, and other parts of the Christian world. The crusaders organized their states in the Near East according to the feudal system. Feudalism reached its height between the 800's and 1200's. By the 1400's, it had become outdated.

The beginnings of feudalism. Feudalism had two main roots. One was the relationship of honour that existed among the Germanic war bands that wandered over much of Europe in the early Middle Ages. The leader and warriors of these bands pledged their loyalty to each other. The warriors fought for the honour of their leader and were expected to remain with him even to death. In turn, the leader was responsible for his men and rewarded them with treasures and glory.

The second main root of feudalism was the system of *tenure* (landholding). Under this system, a lord would grant land to a person on certain conditions or in return for services other than rent or payment. People who owned land might turn it over to a lord in return for protection. The lord allowed the people to stay on the land as tenants. These tenants became the peasants of the manorial system. Although they lost their independence with such an arrangement, having the protection of a powerful local lord was more important to them. The system of tenure was already in use in the former provinces of the Roman Empire when the Germanic invaders settled there in the A.D. 400's.

By the 700's, the Muslims had spread from Africa to Spain, and their new empire threatened all of western Europe. Kings and important nobles began giving fiefs to free and noble warriors in return for military service. These fiefs included land, the buildings on it, and the peasants who lived and worked on it. The warriors who received the fiefs were called *vassals,* from a Latin word meaning *military retainer*. By the 800's, the relationship of honour and loyalty that existed between leader and warrior in the Germanic war bands was combined with a system for holding land and providing services in exchange. The combination of these two factors was feudalism.

A knight armed for battle in the 1200's carried a cross-hilted sword and a kite-shaped shield. His helmet completely covered his head. Other knights could identify him only by his heraldic symbol. The symbol of the Flemish lion that appears on the shield and horse's coverlet in this seal identifies the knight as Guy de Dampierre, the Count of Flanders.



Henry I's nightmares were illustrated in John of Worcester's *Chronicle,* in about 1140. The sleeping king is shown dreaming about problems of being a king, represented by requests from churchmen and peasants, and by violent barons.

The principles of feudalism. Only noblemen or aristocratic warriors could take part in feudal practices. A saying of the time stated, "No land without a lord, and no lord without land." A man became a vassal of the lord in a ceremony called *homage.* The future vassal promised to be loyal, fight for the lord, and become his *man* (*homo* in Latin). The lord promised to treat the vassal with honour. See **Homage**.

After performing homage, the new vassal was *invested with* (given the rights to) his fief. This was done in an *investiture* ceremony. At the ceremony, the lord often gave his vassal a clod of dirt, a stick, or some other such object as a symbol of the fief.

The vassal received only the use or possession of the fief, not ownership of it. He held the fief in return for services he had promised. As long as the vassal held the fief, he received what the land—and the peasants—produced, collected taxes, held court, administered justice, and managed the peasants' labour. When the vassal died, his son usually took over the fief. The son provided the same services as his father.

By 1100, it had become the custom for a man's oldest son to inherit the fief. This custom was called *primogeniture* (the right of the first-born). Primogeniture ensured that the fief would not be broken up among many sons and that one heir would assume responsibility for the services to the lord. See **Primogeniture**.

If a vassal died without heirs, the fief *escheated* (went back) to the lord. The lord could then grant it to another person as he wished. If the dead vassal's heir was a young child, the lord had the right of *wardship* and became the protector of the *ward* (child). The lord could grant the wardship to another vassal, who held the fief and its profits until the young heir came of age. In many cases, the lord also had a right to choose marriage partners for his wards and for the daughters or widows of his vassal. If a woman inherited a fief, her husband performed homage and became the lord's vassal. Such rights of the lord were called feudal *incidents.* They were sources of power and profit for the lord.

The lord had other rights called *aids.* All vassals had to make a special payment when the lord's oldest son was knighted and when his oldest daughter married. If the lord was captured and held for ransom, the vassals had to pay the ransom. But feudal aids and rights were limited. For example, a lord could not require new conditions or levy higher taxes on his vassals. The lord also was supposed to consult his vassals before making major decisions, such as whether or not to go to war.

Knighthood under feudalism. A vassal's main service to his lord was military. By the 700's, vassals had to supply a certain number of knights to serve the lord for a certain number of days, usually 40. Knights were armoured warriors on war horses. The larger the fief held by a vassal, the more knights the vassal had to provide.

It became the custom for a vassal to divide his own fief and distribute parts of it to his knights. The knights then became his vassals. This practice was called *subinfeudation.* By the 1200's, it had developed so far that several layers of feudal relations might separate a knight at the bottom from a baron or a king. At each level, a noble was both lord and vassal.

From the Harley Manuscript of *Froissart's Chronicles.* The British Library, London

Feudal courts settled differences among nobles. This miniature shows England's King Richard II presiding over his royal court. The king gave the final verdict on the advice of his vassals, who were nobles and church officials. This court settled a dispute in 1398 between Thomas Mowbray and Henry of Bolingbroke (later King Henry IV) by banishing both men from England.

Justice under feudalism. Quarrels among vassals were settled at the lord's *court,* which consisted of all the vassals. Many of the legal customs developed at the feudal court have become part of the legal systems of Great Britain and other countries. For example, the lord presided over feudal courts. In courts today, a judge presides. A vassal received judgment from other vassals who were his *peers* (social equals). Today, citizens receive judgment from their peers on a jury. Other judicial customs of feudal days have disappeared. One such custom was *trial by combat,* which involved a fight between the vassals involved in a dispute. The winner of the fight was also declared the winner of the case. It was accepted that God gave victory to the honest vassal or correct side. See **Trial by combat**.

A vassal had to answer the *summons* (order to appear) of a feudal court. If the vassal failed to appear or did not obey the court's decision, the lord could take back the vassal's fief. A rebellious vassal was declared a *felon.*

The lord was expected to seek the advice and consent of his vassals before making laws. In time, this practice led to the idea that no ruler can make laws without the consent of the people being governed. Modern parliaments in Europe developed from the meetings of vassals summoned by a lord or a king.

The decline of feudalism. By the 1200's, several events in Europe led to the decline of feudalism. An economic revival put more money back into use. Because soldiers could be paid, fewer lords relied on vassals to provide the services of knights. The invention of gunpowder and of such weapons as the longbow and the cannon lessened the dominance of knights. Foot soldiers from Flemish cities defeated French knights at the battle of Courtrai in 1302. English longbowmen beat the French cavalry in battles at Crécy in 1346, Poitiers in 1356, and Agincourt in 1415. Stone castles occupied by feudal lords no longer could stand against cannons. Cities grew wealthier and became more important, and rulers had less need of the aristocracy. People trained in government service took over the functions that vassals had performed on their fiefs.

Related articles in *World Book* include:
Castle
Clothing (Middle Ages; Renaissance)
Heraldry
Homage
Knights and knighthood
Manorialism
Middle Ages
Primogeniture
Serf
Trial by combat

Feuerbach, Ludwig Andreas (1804-1872), was a German philosopher. He studied under G. W. F. Hegel, but later turned from Hegel's philosophical idealism and instead stressed the importance of the scientific study of humanity.

In *Thoughts on Death and Immortality* (1830), Feuerbach challenged Christian doctrines. However, Feuerbach actually placed a high value on religion, because he thought it expressed, in an inverted form, humanity's idea of its true essence. Feuerbach presented this idea in his major work, *The Essence of Christianity* (1841). He argued that though religion represents human creative activity as if it depends on God, in reality God is just the projection of an ideal image of humanity's own capacities.

Feuerbach also believed philosophers such as Hegel had an excessively abstract view of human nature, and had missed the significance of concrete physical experience. Thus he declared that *Der Mensch isst was er ist* (Man is what he eats). These ideas influenced Karl Marx. However, Marx and other radicals attacked Feuerbach for merely criticizing views of the human condition, rather than acting directly to improve it. Feuerbach was born in Landshut, in Bavaria.

Fever is a condition in which the body temperature is raised to a higher than normal level. It is one of the most common symptoms of disease. When fever is the main symptom of a disease, it may be part of the disease's name, as in *scarlet fever* or *yellow fever.* The medical term for fever is *pyrexia.*

Not every rise in body temperature is a fever. For example, exercising in the heat or sitting in a sauna can produce an above-normal body temperature. But in these cases, unlike what happens in a fever, the brain instructs the body to decrease its temperature by sweating and increasing skin blood flow, and the individual feels the urge to be in a cool place.

Fever results when an infection or an allergic or toxic reaction causes the brain's temperature setting to rise. For example, when a flu virus enters the human body, white blood cells release a protein called *endogenous pyrogen* or *leucocyte pyrogen.* This protein travels through the blood to the *hypothalamus,* the part of the brain mainly responsible for regulating body temperature. The protein triggers the release of chemical compounds called *prostaglandins.* Prostaglandins act on nerve cells to produce a sensation of coldness. This causes the hypothalamus to increase body temperature by making the body burn fat, decrease skin blood flow, shiver, and develop an urge to stay warm. *Antipyretic drugs,* such as aspirin and paracetamol, reduce fever by slowing the production of prostaglandins.

Medical research has shown that fevers speed up the body's defences against invading viruses and bacteria. Because fever thus can help fight infection, some medical experts advise against reducing a moderate fever. In human beings, a body temperature of 36.9° C is normal. A moderate fever generally ranges from 37.7° C to 38.9° C. A rise in temperature above 40.5° C may cause delirium. Most experts agree that fevers probably should be reduced if they rise above 38.9° C, or if they occur in pregnant women, people with heart disease, or the elderly.

Fever occurs in all *vertebrates* (animals with backbones). Fever first appeared at least 300 million years ago as a means of fighting disease. Among warm-blooded vertebrates—that is, birds and mammals—fever is achieved by physical and behavioural changes. Cold-blooded vertebrates, such as fish and reptiles, achieve a fever by moving into the heat, where they can maintain a high body temperature.

The feverfew is so named because people once believed the plant could cure fever.

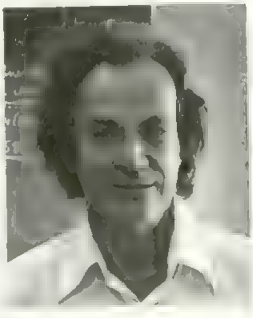
Fever blister. See **Cold sore; Herpes.**

Feverfew is a low, hardy plant that requires little attention. Its cluster of small, white, daisylike flowers appears in late summer. The leaves of the plant have a strong scent when crushed. People once believed that feverfew could cure fever. Its name means *to put fever to flight.*

Scientific classification. Feverfew is a member of the composite family, Compositae (Asteraceae). It is classified as *Chrysanthemum parthenium.*

Feynman, Richard Phillips (1918-1988), of the United States, shared the 1965 Nobel Prize for physics with Julian S. Schwinger and Sin-itiro Tomonaga. Working independently, the three men developed an improved theory of quantum electrodynamics in the late 1940's. *Quantum electrodynamics* is the study of the interaction of atomic particles and electromagnetic radiation. The theory enables scientists to predict accurately the effects of electrically charged particles on each other in a radiation field.

Feynman was born in New York City. He earned a Ph.D. degree from Princeton University, New Jersey, in 1942. From 1942 to 1945, he worked on the atomic bomb project at Los Alamos, New Mexico. He became a professor of theoretical physics at Cornell University, New York, in 1945. He served on the faculty of the California Institute of Technology from 1951 until his death in 1988.



Richard Feynman

Fez, also spelled *Fès* (pop. 325,327), is the religious centre of Morocco and one of its traditional capitals. It boasts the Mosque of Mulai Idris, a noted Muslim shrine, and Karaouiyine University, one of the world's oldest universities. The university was founded in 859.

Fez lies in the deep valley of the Fez River in northern Morocco (see **Morocco** (map)). Railways connect it with other North African cities. It is noted for its silk, woollens, and leather goods. The Moorish ruler Idris II founded Fez as his capital in 808. The city declined in the 1600's, when Sultan Ismail built his palace in Meknès. But it again became the capital from 1728 until the French occupied Morocco in 1912.

Fez is a tall, red, brimless cap with a coloured tassel of silk or wool. It is worn in Egypt and in North Africa, where it is sometimes called a *tarboosh.* All fezzes were once coloured with a dye made from the juice of red berries found only in Morocco. This same colour can now be produced by chemical dyes. The fez was first made in Fez, Morocco.

Fianna Fáil is the largest political party in the Republic of Ireland. The name *Fianna Fáil* means *soldiers of destiny.* Éamon de Valéra founded the party in 1926 and gained the support of people who opposed the treaty that had established the Irish Free State in 1922. Fianna Fáil won power in a general election in 1932. Since then, it has held government office for most of the time.

Charles Haughey became leader of Fianna Fáil in 1979, after Jack Lynch resigned. He held office as *taoiseach* (prime minister) from 1979 to 1981, and for most of 1982. In 1987, Fianna Fáil narrowly failed to win an overall majority of seats in *Dáil Éireann.* But Haughey was again elected taoiseach, and the party formed a minority government. Albert Reynolds was elected party leader and taoiseach in 1992, after Haughey resigned. From 1993 until 1994, Fianna Fáil formed a coalition government with the Labour Party. In 1994, Reynolds was succeeded by Bertie Ahern.

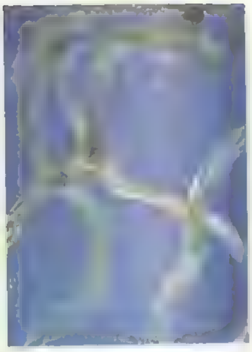
See also **Ahern, Bertie; Ireland, History of** (Independence); **Oireachtas; Reynolds, Albert.**

Fiat, in government, is an executive order or decree that requires obedience but is not a law. Many legal scholars consider a fiat to be an order issued for purposes other than legislation. Such orders sometimes come into conflict with one or more laws. In many cases, conflicts are resolved by the courts. The term *fiat* comes from a Latin word meaning *let it be done.*

Fibonacci, Leonardo (1175?-1240?), was an Italian mathematician who helped introduce the Hindu-Arabic numerals (0, 1, 2, 3, 4, 5, 6, 7, 8, 9) into western Europe. He is also known as the originator of a special series of numbers, now called the Fibonacci sequence or the Fibonacci numbers.

Fibonacci was born in Pisa, Italy, and he is sometimes known as Leonardo of Pisa. In his youth, he travelled in the Middle East, where he learned the Hindu-Arabic numeral system. In 1202, Fibonacci published *Liber Abaci* (*Book of the Abacus*), explaining Hindu-Arabic numerals, methods of arithmetic, and applications to commercial problems. At the time, European merchants were using the Roman numeral system (see **Decimal system**).

In *Liber Abaci*, Fibonacci also explained his famous sequence. This sequence consists of the numbers 1, 1, 2, 3, 5, 8, 13, and so on. Each number after the first two numbers (1, 1) equals the sum of the two numbers before it—that is, $1 + 1 = 2$, $1 + 2 = 3$, $2 + 3 = 5$, and so on. Since their introduction, these numbers have been much studied by mathematicians.



Wool and nylon fibres show the difference between organic and synthetic fibres. Organic wool fibres, *left,* have a scaly structure similar to human hair. Synthetic nylon fibres, *right,* have a smooth surface that makes them resistant to wear.

Fibre is a hairlike strand of a substance that is extremely long in relation to its width. A fibre is at least 100 times longer than it is wide. Fibres are flexible and may be spun into yarn and made into fabrics. A fibre is the smallest visible unit of any textile product. Manufacturers use fibres in clothing and in such home furnishings as carpets, curtains, and upholstery. They also use fibres in many industrial products, including parachutes, fire hoses, insulation, and space suits. In medicine, fibres are used to make artificial arteries and tendons.

Natural fibres include cotton, silk, and wool. There are two types of manufactured fibres. *Regenerated fibres* are made from natural materials. Manufacturers process these materials to form a fibre structure. *Synthetic fibres* are made entirely from chemicals.

The earliest evidence of fabric is a fragment of linen found in what is now southern Turkey, dated between 8000 and 7000 B.C. Wool fabrics date from about 6000 B.C. Cotton was used in about 2700 B.C. The Chinese discovered silk in 2640 B.C. The first practical manufactured fibre, rayon, was developed in 1885.

All natural fibres except silk are limited in length to between about 1 and 20 centimetres. The length of a silk fibre depends upon the size of the silkworm's cocoon. Fibres of limited length are called *staple fibres.* Manufacturers spin these fibres into yarn. Manufactured fibres are not limited in length. They are produced in long, continuous strands called *filament fibres.* They can be used singly as yarns or blended with other filament fibres. When they are blended with natural fibres, filaments are cut into staple lengths.

The properties of a particular fibre depend on its chemical composition and physical structure. Manufacturers use fibres that have properties suited to their products. For example, fibres used in clothing must feel pleasant to the touch, be absorbent, have a good lustre, and drape to fit the body. For industrial use, a fibre's strength and durability are important. One such fibre, SPECTRA-900, is 10 times stronger than steel. Another class of fibres, *spandex,* can stretch like rubber.

Natural fibres

Natural fibres are obtained mainly from plants and animals. They account for more than half the fibres produced in the world each year.

Plant fibres. *Cotton* is the most widely used natural fibre. Staple fibres from cotton *bolls* (seed pods) are spun into yarns for clothing, and household and industrial fabrics. Cotton cloth is absorbent, soft, and comfortable to wear. *Flax,* a strong fibre from the stems of flax plants, is used to make clothing and linen products. *Hemp, jute,* and *sisal* are coarse plant fibres used in cords, ropes, and rough fabrics.

Animal fibres include fur and hair. *Wool,* the hair sheared from sheep and certain other animals, is popular in clothing and home furnishings. Wool fibres have a scalelike surface that resembles shingles on a roof. Manufacturers mat wool fibres together in a process known as *felting.* This process produces air pockets within the matted fibres. Air trapped in these pockets acts as an insulator. This is one reason wool clothing keeps a person warm. *Silk* is the strongest natural fibre. Manufacturers unwind silk filaments from silkworm cocoons and make silk yarn for clothing and decorative fabrics.

Manufactured fibres

The study of plastics has helped chemists learn how to combine chemicals to create fibres that have specific properties. Machines melt the chemicals or mix them in various liquids. The machines then force streams of the chemicals through tiny holes. The streams harden into filament fibres that are wound onto spools or cut into staple lengths.

The two main groups of manufactured fibres are regenerated fibres and synthetic fibres.

Regenerated fibres are also called *cellulosics* because they are derived from the cellulose in cotton and wood pulp. Manufacturers process cotton and wood pulp to make such cellulosics as *rayon,* the first successful manufactured fibre. Rayon has many properties that resemble those of cotton. Cellulose treated with acetic acid produces *acetate,* a fibre that is silkier than rayon. Rayon and acetate are used in clothing, and rayon is also used in tyres.

Synthetic fibres are manufactured from chemicals. Most synthetic fibres are stronger than either natural or regenerated fibres. Synthetic fibres, as well as the regenerated fibre acetate, are *thermoplastic* (softened by heat). Manufacturers are able to shape these fibres at high temperatures, adding such features as pleats and creases. These fibres will melt if touched with too hot an iron. The most widely used kinds of synthetic fibres are (1) nylon, or polyamide, fibres, (2) polyester fibres, (3) acrylic fibres, and (4) olefin fibres.

Nylon fibres, or *polyamide* fibres, were the first synthetic fibres. In 1935, the American chemist Wallace Carothers developed the first such fibre, now called nylon 66. Nylon fibres are lightweight and strong, and are widely used in carpets, hosiery, ropes, and tyres.

Polyester fibres, such as Terylene, Fortrel, Kodel, and Trevira, are durable and quickly regain their shape after being stretched or wrinkled. They are used in clothing and bedding. Clothing fabrics are often made from a blend of polyester and cotton fibres. The polyester fibres provide wash-and-wear characteristics, and the cotton fibres make the fabrics comfortable to wear. Manufacturers also use polyester fibres in filters, sails, and other industrial fabrics.

Acrylic fibres, including Acrilan, Creslan, and Orlon, are soft and durable. A number of acrylic yarns resemble wool and are used in clothing, especially sweaters. Many artificial furs also are made from acrylic fibres.

Olefin fibres are strong and resist stains. These properties make Herculon, Marvess, and other olefin fibres useful in carpets, upholstery, and ropes.

Other synthetic fibres. Yarns called *Lastex* are made from manufactured rubber fibres wrapped in cotton, nylon, or other fibres. Lastex and *spandex,* a group of elastic fibres including Lycra and Glospan, add stretch to garments. Special metal treatments produce *metallic fibres,* such as gold and silver filaments, that can be used to decorate fabrics.

Related articles in ***World Book*** include:

Natural fibres

Abacá	Hemp	Ramie
Asbestos	Henequen	Silk
Cotton	Jute	Sisal
Flax	Kapok	Wool

Manufactured fibres

Acrylic	Nylon	Rayon
Fibreglass	Polyester	

Other related articles

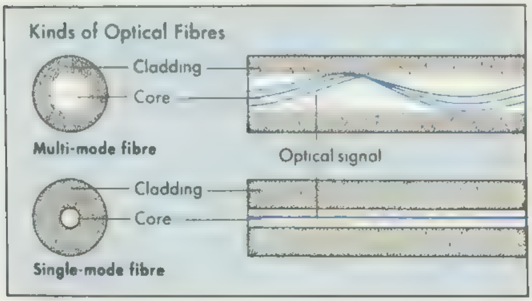
Agriculture (Natural fibres)	Mohair	Textile
Cellulose	Palm	Thread
Linen	Plastics	Wallboard

Fibre optics is a branch of physics based on the transmission of light through transparent fibres of glass or plastic. These *optical fibres* can carry light over distances ranging from a few centimetres to more than 160 kilometres. Such fibres work individually or in bundles. Some individual fibres measure less than 0.004 millimetre in diameter.

Optical fibres have a highly transparent core of glass or plastic surrounded by a covering called a *cladding.* Light from a laser, a light bulb, or some other source enters one end of the optical fibre. As the light travels through the core, it is typically kept inside it by the cladding. The cladding bends or reflects—inward—light rays that strike its inside surface. At the other end of the fibre, the light is received by a detector, such as a photosensitive device or the human eye.

Kinds of optical fibres. There are two basic kinds of optical fibres—*single-mode fibres* and *multi-mode fibres.* Single-mode fibres are used for long-distance transmissions. They have extremely small cores, and they accept light only along the axis of the fibres. As a result, single-mode fibres require the use of special lasers as a light source, and they need to be precisely connected to the laser, to other fibres in the system, and to the detector. Multi-mode fibres have cores larger than those of single-mode fibres, and they accept light from a variety of angles. Multi-mode fibres can use more types of light sources and cheaper connectors than can single-mode fibres, but they cannot be used over long distances.

A thin optical fibre can transmit as much information as a larger, traditional copper cable, *above*. There are two basic kinds of optical fibres, *below*. A *multi-mode fibre* has a wide core that allows light to travel along many paths. The narrow core of a *single-mode* fibre confines light to a central path.



Uses of optical fibres. Optical fibres have a number of uses. In fibre-optic communication systems, special lasers transmit coded messages by flashing on and off at extremely high speeds. The messages travel through optical fibres to interpreting devices that decode the messages, converting them back into the original signal. Fibre-optic communication systems have a number of features that make them superior to systems that use traditional copper cables. They have a much larger information-carrying capacity and are not subject to electrical interference. Signals sent over long-distance fibre-optic cables need less amplification than do signals sent over copper cables of equal length. Many communication companies have installed large networks of fibre-optic cables. Underwater fibre-optic cables carry signals across the Atlantic and Pacific oceans.

Optical fibres are well-suited for medical use. They can be made in extremely thin, flexible strands for insertion into the blood vessels, lungs, and other hollow parts of the body. Optical fibres are used in a number of instruments that enable doctors to view internal body parts without having to perform surgery (see **Arthroscopy**). Surgical lasers and devices for measuring temperature or pressure also use optical fibres.

See also **Communication** (Communication of the future; picture: Fibre-optic communication); **Laser; Telecommunication; Telephone** (Recent developments).

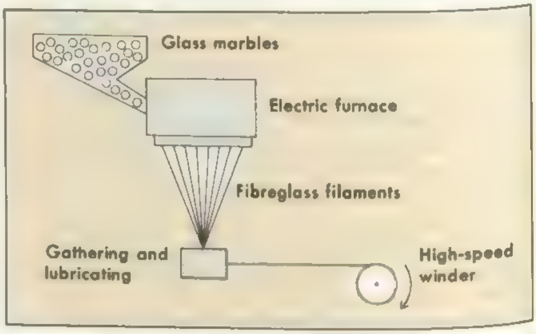
Fibreboard is a building material made of wood or other plant fibres pressed into sheets. Builders use it as insulation, as wall covering, and as a base for plastering and floor covering. It is also used for making furniture. Manufacturers make fibreboard chiefly from wood, but also use waste paper, straw, sugar cane, and maize stalks. Other materials, such as asphalt and rosin, may be added to increase strength or resistance to fire, decay, or moisture. See also **Wallboard.**

Fibreglass, also called *fibrous glass,* is glass in the form of fine *fibres* (threads). The fibres may be many times finer than human hair, and may look and feel like silk. The flexible glass fibres are stronger than steel, and will not burn, stretch, rot, or fade.

Uses. Manufacturers use fibreglass to make a variety of products. Fibreglass is woven into cloth to make such products as curtains and tablecloths. The cloth does not change its properties when dyed. It will not wrinkle or soil easily, and needs no ironing after washing. Fibreglass textiles are also used for electrical insulation. In bulk form, fibreglass is used for air filters and for heat and sound insulation. Air trapped between the fibres makes it a good insulator.

Fibreglass-reinforced plastics are extremely strong and light in weight. They can be moulded, shaped, twisted, and poured for many different uses. Manufacturers use fibreglass-reinforced plastics to make car bodies, boat hulls, building panels, fishing rods, and aircraft parts. The fibres used to strengthen plastic may be woven or matted together, or they may be individual strands. The form used depends on the nature and price of the final product.

How fibreglass is made. Fibreglass is made from sand and other raw materials used to make ordinary glass (see **Glass** [Recipes for making glass]). Strands of fibreglass may be made in different ways. In one method, the raw materials are heated and formed into small glass marbles so workers can examine them for impurities. The marbles are then melted in special electric furnaces. The melted glass runs down through tiny holes at the bottom of the furnace. A spinning drum catches the fibres of hot glass and winds them onto bobbins, like threads on spools. Because the drum revolves much faster than the glass flows, tension pulls the fibres and draws them out into still finer strands. The drum can pull out 3.2 kilometres of fibres in a minute. More than 150 kilometres of fibre can be drawn from



Fibreglass is often made by melting glass marbles in a furnace. The melted glass flows through tiny holes at the bottom of the furnace and comes out as fine filaments. The filaments are then gathered together, lubricated, and wound around a reel.

one marble 16 millimetres in diameter. The fibre can be twisted together into yarns and cords. The yarns may be woven into cloth, tape, and other kinds of fabrics. In another method, called the *direct melt process,* the marble-making steps are omitted.

Bulk fibreglass, or *fibreglass wool,* is made somewhat differently. Sand and other raw materials are melted in a furnace. The melted glass flows from tiny holes in the furnace. Then high-pressure jets of steam catch it and draw it into fine fibres from about 20 to 38 centimetres long. The fibres are gathered on a conveyor belt in the form of a white wool-like mass.

History. The Egyptians used coarse glass fibres for decorative purposes before the time of Christ. Edward Drummond Libbey, an American glass manufacturer, exhibited a dress made of fibreglass and silk at the Columbian Exposition in Chicago in 1893. During World War I, fibreglass was made in Germany as a substitute for asbestos. Finally, in experiments conducted from 1931 to 1939, two American companies, the Owens Illinois Glass Company (now called Owens-Illinois, Inc.) and the Corning Glass Works, developed practical methods of making fibreglass commercially.

Fibrillation. See Heart (Fibrillation).

Fibrin is a white, fibrous protein substance that makes up the most important part of a blood clot. The formation of a clot is called *coagulation.* Fibrin is formed from *fibrinogen,* a protein that is present in *plasma* (the liquid portion of the blood). When blood flows out of a cut area, molecules of fibrinogen unite to become long fibres of fibrin. These fibres make a meshlike plug over the cut area. Red blood cells become caught in the mesh and help form the blood clot. Clots may also form inside blood vessels.

Fichte, Johann Gottlieb (1762-1814), was a German philosopher. He strongly influenced German metaphysics, aesthetics, and social thought. Fichte also influenced philosophers Friedrich Schelling and G. W. F. Hegel.

Fichte was a follower of the idealism of German philosopher Immanuel Kant. Fichte believed that the mind is the essence of the universe. Our ideas, he maintained, do not come from experience of the material world. Instead, our minds are part of the universal creative mind. Fichte dealt with these ideas in his *Foundation of the Complete Theory of Knowledge* (1794). His chief political work is the patriotic *Addresses to the German Nation* (1808). In it, Fichte expressed his faith in German culture and national spirit. The book had a major impact on German nationalism.

Fichte was born in Rammenau, near Bautzen, in Germany. He taught at the University of Jena from 1794 to 1799. He was a popular lecturer but lost his position after being accused of atheism. He served on the faculty of the University of Berlin from 1810 until his death.

Fiction is a story created from an author's imagination. It may be written in prose or verse. Novels and short stories are the most popular forms of fiction. Other forms include dramas and *narrative poems* (poems that tell a story). Fiction differs from biographies, histories, and other *nonfiction,* which is created entirely from facts. The word *fiction* comes from the Latin word *fictio,* which means *a making* or *a fashioning.*

Characteristics of fiction. All fiction contains elements that are partly or entirely imaginary. Such elements include characters and settings. In some fiction, the imaginary elements are obvious. For example, *Alice's Adventures in Wonderland* (1865), by the English author Lewis Carroll, has wildly unrealistic characters and events. But fiction does not necessarily differ much from reality. Many fictional works feature true-to-life characters and realistic settings, and some fiction is based on real people and real events. For example, Napoleon's invasion of Russia in 1812 is the background of *War and Peace* (1869), a novel by the Russian writer Leo Tolstoy. The factual elements in fiction are always combined with imaginary characters, situations, and incidents.

The chief purpose of most fiction is to entertain. But a serious work of fiction also stimulates the mind. By creating characters, placing them in specific situations, and establishing a point of view, writers of serious fiction set forth judgments. These judgments may involve moral, philosophical, psychological, or social problems. They also may concern the nature of fiction. For example, an author may deliberately baffle the reader regarding how fiction should be presented.

History. Storytelling is as old as humanity. It is believed that prehistoric people passed on myths and legends from generation to generation by word of mouth and through drawings. Fiction has appeared in a wide variety of forms since the development of writing about 5,000 years ago. But certain general forms have been dominant during various eras.

The most popular forms of fiction in ancient times included the *epic* and the *fable.* Epics are long narrative poems about heroes or gods. Two of the most famous epics, the *Iliad* and the *Odyssey,* were probably written by the Greek poet Homer in the 700's B.C. Fables are brief tales with a moral. Among the best-known fables are the animal stories attributed to the Greek slave Aesop, who lived about 600 B.C. See **Epic; Fable.**

From the 1100's to the 1400's, during the Middle Ages, the *romance* became the leading form of fiction. Most medieval romances tell about adventures of knights or other court figures. Many of these stories have supernatural characters and events. See **Romance.**

Since the mid-1700's, the chief forms of fiction have been the novel and the short story (see **Novel; Short story**). In some modern works, the authors have abandoned traditional storytelling devices, such as organized plots and clear-cut characters. For example, the novels of the French author Alain Robbe-Grillet feature precise descriptions of events and objects as experienced or seen by the characters. Such works intentionally confuse the reader.

Related articles. See the articles on national literatures, such as **English literature** and **French literature.** See also:

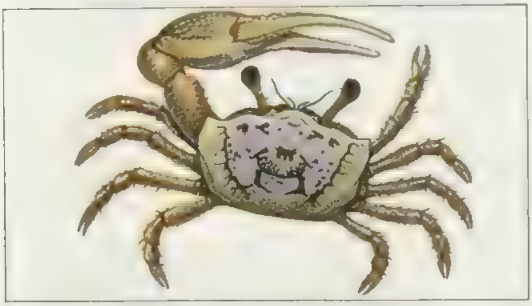
Detective story	Poetry
Drama	Science fiction
Literature for children (Fiction)	

Fiddleback spiders are venomous spiders native to the Mediterranean region. The spiders are about a centimetre long, lightly built, and have slender legs. They are brownish in colour, often with a darker fiddle-shaped mark extending back from the head region. This spider's bite is not fatal, although related species have caused deaths. The bites do result in wounds that are unsightly and rather slow healing.

Fiddleback spiders are found in the Adelaide-Port Augusta region of South Australia, where they were probably originally introduced through ships' cargoes in the 1930's.

Scientific classification: Fiddleback spiders belong to the family Sicariidae and subfamily Loxoscelinae. They are *Loxosceles rufescens.*

Fiddler crab is a burrowing animal that lives along sandy or muddy beaches and salt marshes in tropical and temperate regions. It belongs to the class Crustacea. The male has a huge front *pincer* (claw) that he moves



The fiddler crab lives in sandy or muddy soil. The male, *above,* uses its huge front claw in fighting other males.

back and forth much as a fiddler moves his or her arm when playing a violin. This claw is used for courting females and for fighting with other males. The fiddler crab feeds on water plants, called *algae,* mixed with mud. In the autumn, the crabs in cold regions close their burrows and hibernate.

Scientific classification. The fiddler crab belongs to the order Decapoda. It makes up the genus *Uca.* There are various species.

See also **Biological clock** (Other rhythms); **Crab.**

Fiedler, Arthur (1894-1979), conducted the Boston Pops Orchestra from 1930 to 1979. He organized and conducted the Boston Sinfonietta, later known as the Arthur Fiedler Sinfonietta, and the Boston Esplanade Concerts. Fiedler was born in Boston, Massachusetts, U.S.A., and studied at the Royal Academy of Music in Berlin. He taught at Boston University.

Fief. See **Feudalism.**

Field was the family name of three distinguished sons of David Dudley Field (1781-1867), a well-known American Congregational clergyman and the author of several histories of the U.S. state of Massachusetts.

David Dudley Field, Jr. (1805-1894), a brilliant lawyer, won recognition for his work as a reformer of legal procedure. He started work on a code of legal procedure in 1847. His code formed the basis for legal procedure reforms in many U.S. states and in England.

David became the first president of the International Law Association, founded in Brussels in 1873 to reform and codify international law. He was born in Haddam, Connecticut, U.S.A., and studied at Williams College, Massachusetts, U.S.A.

Stephen Johnson Field (1816-1899) was an associate justice of the Supreme Court of the United States from 1863 to 1897. He handed down many opinions that helped develop United States constitutional law. He also served on the Electoral Commission in 1877. Stephen was born in Haddam, Connecticut, and graduated from Williams College, Massachusetts.

Cyrus West Field (1819-1892) promoted the first telegraph cable across the Atlantic (see **Cable**). The first fully successful cable was laid in 1866, after four previous attempts.

The first cable, laid in 1857, broke 580 kilometres from shore. An attempt in June 1858 also failed. Field promoted a successful effort to lay a cable between Ireland and Newfoundland, Canada, in August 1858. Technical carelessness ruined the cable's insulation, and it failed four weeks later. In 1865, Field attempted to lay a new cable. The cable broke when the project was almost completed. The project succeeded in 1866, with the laying of a new cable and the repair of the old.

Field later promoted the New York City elevated railway. He also wanted to lay a cable to the Hawaiian Islands, Asia, and Australia. Field was born in Stockbridge, Massachusetts, U.S.A.

Field, John (1782-1837), was an Irish-born composer and pianist who won international fame in Europe for his delicate romantic pieces known as *nocturnes.* Some musical scholars think that Field invented the nocturne. All agree that he brought the form to an early maturity and inspired Chopin.

Born in Dublin, Ireland, Field began composing and playing in public at the age of 9. In 1802, the teacher and piano maker Muzio Clementi took him to St. Petersburg, in Russia. Field's playing won high praise there, and he eventually settled in Moscow.

Field event. See **Athletics.**

Field glasses. See **Binoculars.**

Field-ion microscope. See **Ion microscope.**

Field magnet. See **Electric motor** (Parts of an electric motor).

Field marshal. See **Marshal.**

Field names may describe the shape of fields, their quality, or their location. Some fields are named after people or historical events. Words like *brade, balk, flat,* and *shute* refer to strips in the open fields of medieval times. Some field names come from old words for *pasture* or *animal enclosure.* A variety of fanciful names, nicknames, and ironic names have also been given to fields.

Field of force. See **Force.**

Field spaniel is a gundog. For many years, owners separated field spaniels from cockers and other kinds of spaniels on the basis of size alone. The dog they called the field spaniel stands about 45 centimetres high and weighs 16 to 23 kilograms. It has a flat, glossy coat, usually black or some other solid colour.

The field spaniel breed originated in England in the 1700's. This spaniel is intelligent and has great perseverance in seeking out and retrieving shot birds and other game.

Fielding, Henry (1707-1754), an English author, wrote *The History of Tom Jones, a Foundling* (1749), one of the world's great novels. The book is an exciting, humorous story of an orphan and his adventures. Although it begins when Tom is a baby, most of the story concerns the hero as a young man. Tom's many adventures include a variety of love affairs, ranging from passing encounters to his true love for Sophia Western.

In *Tom Jones,* Fielding did more than create a humorous adventure story. He skilfully incorporated the plot's many twists into a unified structure, beginning each of the novel's 18 *books* (chapters) with a brilliant and related essay. He filled his story with unforgettable characters whom he described in a sophisticated and lively style. These qualities greatly influenced later novelists, as did Fielding's realistic, basically unsentimental attitude toward life. Fielding ridiculed hypocrites and selfish people but avoided a preaching tone. His tongue-in-cheek irony makes *Tom Jones* an outstanding satire on society.

Detail of an engraving by William Hogarth, The British Museum, London

Henry Fielding

Fielding's novel *Joseph Andrews* (1742) is a *parody* (mock imitation) of *Pamela,* Samuel Richardson's serious novel about the rewards of a virtuous life. *The Life of Jonathan Wild the Great* (1743) is fictional, but its criminal hero was a real person whom Fielding treated ironically to contrast "greatness" with "goodness."

Fielding's last novel, *Amelia* (1751), is a relatively sober work. It attacks social evils more directly than *Tom Jones* does. However, *Amelia* is less successful as a novel.

Early in his career, Fielding supported himself by writing plays. The most enjoyable is *The Tragedy of Tragedies; or, The Life and Death of Tom Thumb the Great* (1730-1731), a burlesque of English heroic drama. *Pasquin* (1736) and *The Historical Register for The Year 1736* (1737) attack British Prime Minister Robert Walpole. These satires helped bring about the Licensing Act of 1737, which resulted in strict control and censorship of the London theatre.

Fielding was also an excellent journalist and essayist. In 1752, he published the *Covent Garden Journal,* a satirical review of society and the literature of his time that appeared twice a week. His *Journal of a Voyage to Lisbon,* published in 1755 after his death, describes a trip he made to Portugal in 1754. He died two months after arriving in Lisbon.

Fielding was born near Glastonbury, in Somerset, England. He attended Eton College and then studied law. He became a justice of the peace in 1748. Throughout his life, Fielding fought for social and legal reforms, both as a writer and as a magistrate.

See also **Police** (History).

Fields, Dame Gracie (1898-1979), an English actress and singer, won fame as a stage and film star in the music hall tradition. To people in Lancashire, England, she was known as "Our Gracie" because of her down-to-earth, humorous, and sentimental approach. Her most famous song was "Sally," the theme song of her first film. Gracie Fields was born at Rochdale, in Greater Manchester, England. She was named Grace Stansfield. She first impressed London audiences in the revue *Mr. Tower of London.* She later made records and performed in films and on radio and TV. Gracie Fields retired to the island of Capri in 1950. She was made a Dame Commander of the British Empire in 1979.

Dame Gracie Fields

Fields, W. C. (1879-1946), was an American film comedian. Fields incorporated his personal prejudices into his films, and it became difficult to separate his real personality from his film characters. In his films, Fields often played swindling characters. He was at war with the world, battling both people and objects. He hated children, and they hated him. Fields' trademarks included a

The field spaniel has a glossy coat.

W. C. Fields was a popular stage and film comedian. He and Mae West starred in the film *My Little Chickadee, above.*

top hat, a monstrous nose, and a distinctive side-of-the-mouth manner of speaking.

Fields made his film debut in 1915 in a brief role in a comedy. He was in several silent films but did not win fame until the emergence of sound films. His major films include *The Old-Fashioned Way* (1934), *It's a Gift* (1934), *The Man on the Flying Trapeze* (1935), *David Copperfield* (1935), *You Can't Cheat an Honest Man* (1939), *My Little Chickadee* (1940), *The Bank Dick* (1940), and *Never Give a Sucker an Even Break* (1941).

William Claude Dukenfield, Fields' real name, was born in Philadelphia. He began a vaudeville and musical comedy career at the age of 14.

Fiesta. See **Latin America** (Recreation); **Mexico** (Holidays).

Fife is a small woodwind instrument that belongs to the flute family. It consists of a wooden tube that has from six to eight finger holes along its length and a mouth hole near one end. A player holds the fife in a horizontal position and blows across the mouth hole. The fife produces a shrill, penetrating sound. The player covers and uncovers the finger holes to produce different notes.

The fife originated in Switzerland in the 1500's. It was later used throughout western Europe and in the United States. Traditionally, fifes were played with drums in military units and were associated with patriotic groups. They are now played primarily in ceremonial fife and drum corps.

Fife Region lies on the east coast of central Scotland between the Firth of Tay and the Firth of Forth. It has fertile agricultural land, Scotland's leading coalfield, and important manufacturing towns. The University of St. Andrews in Fife Region is Scotland's oldest university. It was founded in 1412.

Fife Region was created in 1975, when Scotland's local government was reorganized. Previously, Fife had been a county, with the same boundaries as the present Fife Region. Fife's people fought strongly against plans to divide Fife between regions to the north and south. They succeeded, and Fife remained an independent local government unit.

People and government

Local customs. Fishing boats do not sail on Sundays until after church in the evenings. Many people who fish still believe that a member of the clergy boarding their boat will bring bad luck.

St. Andrews University students carry out a tradition following morning service on Sundays. They walk from the university chapel to the end of the harbour pier. Each year, a male student of the university dresses in a medieval woman's clothing. He takes the part of Kate Kennedy in celebrations commemorating the founding of the university.

Recreation. The Royal and Ancient Golf Club at St. Andrews is accepted as the body in charge of golf rules. Fife has four teams in the association football Scottish League—Cowdenbeath, Dunfermline, East Fife, and Raith Rovers. Other popular sports include cricket, ice sports such as curling and skating, Rugby football, sailing, and water-skiing.

Local government. Fife is divided into three local government districts. They are *Dunfermline,* which includes the southwestern part of the region; *Kirkcaldy,* which includes the region's central area; and *North-East Fife,* which covers the northern half of the region.

Economy

Mining. Coal mining is important in southern Fife. The mines have shafts that extend under the Firth of Forth. Fife's collieries employ about 3,000 men and produce more than a third of Scotland's coal-mining output. Opencast mines in central and west Fife produce about half as much coal as the region's deep mines. The coal-mining industry has declined steadily since World War II, causing high unemployment.

Manufacturing. Dunfermline produces textiles and Kirkcaldy produces plastic floor coverings. Rosyth has a Royal Navy dockyard, and oil production platforms are produced at Methil. There are paper mills at Glenrothes, Guardbridge, and Inverkeithing. Glenrothes has a large electronics industry.

Agriculture. In the lowlands, farmers grow barley and rear beef cattle or sheep. Other crops include potatoes near the coast and soft fruit near Cupar. The upland areas of Fife have sheep farming and forestry.

Transport and communications. During the 1960's, Fife's road links with other parts of Scotland were greatly improved. Road bridges were built across the Firth of Forth and the Firth of Tay. The region has a good internal road network. A main railway line from Edinburgh to Dundee crosses the region. Local newspapers are published weekly at Dunfermline and Kirkcaldy. Independent local radio stations in Lothian Region and Tayside Region serve Fife Region.

Tourism is important in the economy of St. Andrews. It is also important to the small towns on the region's south coast, such as Crail and Largo.

Land

Location and size. Fife Region is a peninsula, with the North Sea lying to the east of it. It is bounded to the north by the Firth of Tay and to the south by the Firth of Forth. In the west, it borders on Central Region and Tayside Region. Fife Region's maximum dimensions are about 32 kilometres from north to south and about 72 kilometres from east to west.

Land features. A series of hills, volcanic in origin, extends across the centre of the region. The main groups of these hills are the Cleish Hills and the Lomond Hills. The East Neuk is a plateau area, which forms the most easterly part of Fife. It lies between 15 and 90 metres above sea level and has a rocky shoreline. Tents Moor is a peninsula in the extreme northeast of Fife. It is formed of windblown sand stabilized by plantings of trees.

Rivers. Fife Region's main rivers are the Eden, the Leven, and its tributary, the Ore. The valleys of the Eden

Facts in brief about Fife

Administrative centre: Glenrothes.
Largest towns: Dunfermline, Kirkcaldy, Glenrothes, Buckhaven and Methil, St. Andrews.
Land area: 1,310 km².
Population: *1991 census*—339,284.
Chief products: *Agriculture*—barley, beef, potatoes, sheep, soft fruit, timber. *Manufacturing and mining*—coal, electronic goods, oil production platforms, plastic floor covering, textiles.

Fife Region has many fishing communities along its coast. One of these communities, the attractive village of Crail, lies on the Firth of Forth.

and Leven have some paper-making industries, and some of the region's coal-mining activity is located in the Ore valley.

Climate. Annual rainfall in Fife is low compared with other parts of Scotland. Low-lying areas in eastern Fife receive only about 500 millimetres each year. Some upland areas receive as much as 1,250 millimetres.

In summer, considerable temperature variations result when sea mist, called *haar,* drifts in from the North Sea. Areas engulfed by mist may be as much as 11° C cooler than nearby areas.

History

The region is often called the Kingdom of Fife, reflecting a legend that the area was once a separate province of the Picts.

Fife began to play an important part in Scottish history from the 1000's onwards. King Malcolm III transferred his court to Dunfermline in about 1060, and the town and its abbey prospered. Kings and court visited the town often during medieval times. Robert Bruce is buried in Dunfermline Abbey. During medieval times, the small ports of southern Fife carried on much trade. They exported wool, fish, coal, and metal goods. Their imports included textiles and spices.

A cathedral was established at St. Andrews in 1160. It became the most important church centre in Scotland. Its archbishop became the *primate* (church leader) of Scotland. St. Andrews University was founded in 1412. The Reformation brought destruction of the church's power. Afterwards, Edinburgh gradually grew to overwhelming significance in Scottish life. These factors reduced Fife's importance.

In the early 1800's, with the start of the Industrial Revolution, Fife began to develop again economically. New methods increased the productivity of its farms. New water-powered machinery produced large amounts of linen, and the coal mines expanded rapidly. Many people moved into the area, and the population increased rapidly.

In 1879, the newly completed Tay rail bridge collapsed while a train was crossing it. Remains of this bridge can still be seen beside the bridge that replaced it.

Part of the surrendered German fleet was escorted to Rosyth at the end of World War I. During World War II, one of the earliest air raids, in September, 1939, took place over the Forth Bridge.

Two Scotsmen of international fame were born in the region. Adam Smith, the first great classical economist, was born at Kirkcaldy in 1723. He became professor of

Fife Region is a peninsula on the east coast of central Scotland. It lies between the Firth of Tay and the Firth of Forth.

logic and, later, professor of moral philosophy at the University of Glasgow.

Andrew Carnegie, the multimillionaire, was born in a linen-weaver's cottage in Dunfermline in 1835. In 1848, he emigrated with his family to the United States, where he made a large fortune through his part in the steel industry. He founded many educational institutions. He founded his first library in Dunfermline in 1882.

Related articles in *World Book* include:

Carnegie, Andrew
Industrial Revolution
Reformation
Saint Andrews
Smith, Adam

Fifth column refers to undercover agents operating within the ranks of an enemy to undermine its cause. The agents pave the way for military or political invasion. They may work in an army, political party, or industry. Their activities include spying, sabotage, economic subversion, propaganda, agitation, infiltration, and even, assassination, terror, and revolt. The term *fifth column* was first used during the Spanish Civil War (1936-1939) to describe the work of Francisco Franco's followers in Loyalist Madrid. Emilio Mola, a general under Franco, said, "I have four columns moving against Madrid, and a fifth will rise up inside the city itself."

Fifty-Four Forty or Fight was a slogan used during a boundary dispute between the United States and Great Britain. An 1818 treaty allowed both countries to occupy the Oregon Country, lying between 42° and 54°40' north latitude. In the 1830's and 1840's, American expansionists wanted to take the whole area, by force if necessary. When James K. Polk became President, the United States made a new treaty that set 49° as a boundary, except for Vancouver Island. The United States secured the land south of the line, and Great Britain obtained the land to the north.

Fig is a fruit that has been cultivated for more than 4,000 years. It probably originated in southwest Asia, then spread to the Mediterranean region. Ancient Greek, Roman, and Egyptian documents describe its popularity as a food.

Figs are small and round or pear-shaped. They have green, yellow, pink, purple, brown, or black skins, depending on the variety. They have a high sugar content, and people eat them fresh, dried, canned, or preserved in sugar.

Figs are the fruit of the fig tree, which generally grows in warm climates. The plant's flowers grow inside the fruit.

Figs grow on trees of the same name. Fig trees thrive in climates with hot, dry summers and cool, moist winters. Important fig-producing countries include Portugal, Italy, Greece, and Turkey.

Most fig trees grow to less than 10 metres tall and have a trunk about 1 metre in diameter. The trees have deeply lobed leaves. The fruit develops from podlike structures that grow on the branches and that contain hundreds of tiny flowers. As the fruit develops, these structures enlarge and become fleshy. Fig trees bear two or three crops of fruit each year.

There are four main types of figs: (1) caprifigs or wild figs, (2) Smyrna figs, (3) common or Adriatic figs, and (4) San Pedro figs. Caprifig trees seldom produce edible fruit. Small fig wasps live inside the caprifigs. When the wasps leave the figs, they carry pollen from the flowers. The Smyrna fig depends on these pollen-carrying wasps to pollinate its flowers. All varieties of Smyrna figs require pollen from caprifigs in order to bear fruit. The common fig does not require pollination to produce fruit. The San Pedro fig produces two types of fig crops each year. The first crop, which is harvested in the early summer, develops without pollination, like the common fig. The second crop of the San Pedro fig, which matures in the late summer, must be pollinated by the fig wasp, like the Smyrna fig.

Growers produce new fig trees from branches cut from other fig trees. In most cases, the new trees bear fruit two to four years later. Mediterranean fruit flies and tiny worms called *nematodes* are among the fig tree's most troublesome pests.

Ripe figs spoil easily and cannot be shipped long distances to market. For this reason, most growers dry their crop—either in the sun or in ovens—before shipping to distant markets.

Scientific classification. The fig tree belongs to the mulberry family, Moraceae. It is *Ficus carica.*

Figaro. See Beaumarchais, Pierre A. C. De.

Fightingfish is a small, quarrelsome fish that lives in the waters around the Malay Archipelago. It is often called the *Betta* or *Siamese fightingfish.* It has been bred to develop long waving tails and fins. When the male is excited, it becomes coloured with reds, greens, purples, and blues. Only the male is a fighter. Fightingfish dash at one another, biting the opponent's fins until one of the fish is exhausted. One fightingfish will even attack its own image in a mirror. Watching fights between male fightingfish is a popular sport among the people of Thailand.

Scientific classification. The fightingfish belongs to the family Anabantidae. It is *Betta splendens.*

See also **Fish** (pictures: Fish of tropical fresh waters; A male Siamese fightingfish).

Figure of speech is the use of words in certain conventional patterns of thought and expression. For example, we might read that "The spy was cornered *like a rat* . . . The crowd *surged* forward . . . The *redcoats* withdrew . . . Justice *hung her head* . . . Here was *mercy* indeed! . . . The *entire nation* screamed vengeance."

Each of these figures of speech has its own name. The

Fightingfish grow about 6.5 centimetres long. The male, *bottom,* displays its beautiful tail and fins to the female, *top.*

first is a *simile,* when the spy is directly compared with a rat. The second is a simple *metaphor,* when the author implies that the movement of the crowd is like that of an oncoming wave. The third is a *metonymy,* when the word "redcoats" stands for the soldiers who wear them. The fourth, a *personification,* speaks of justice as though it were a person. The fifth is an *irony,* because the author means the opposite of mercy. The sixth is a *hyperbole,* or exaggeration for special effect.

Figures of speech are the flowers of rhetoric. They give to poetry much of its beauty and fragrance, its sweetness and germinal power. John Milton wrote, in "On His Being Arrived at the Age of Twenty-Three,"

> How soon hath Time, the subtle thief of youth,
> Stolen on his wing my three and twentieth year!
> My hasting days fly on with full career,
> But my late spring no bud or blossom shew'th.

Without consciously analysing the personification, metonymy, and metaphor used, the reader still senses the richness of imagery and poetic thought. Everyday speech also uses many such figures.

See also **Hyperbole; Irony; Metaphor; Metonymy; Simile.**

Figure skating. See **Ice skating.**

Figwort family, also called *Scrophulariaceae,* is a group of about 3,000 species of herbs, shrubs, and small trees. Some of these plants are used in medicines. They have bell-shaped flowers that are divided into two lips. The flowers grow at the top of a slender stem, while the leaves often grow in pairs on the stem. The family flourishes especially in temperate regions. It includes wild flowers and weeds such as mullein, butter-and-eggs, speedwell, and lousewort. The cultivated varieties include foxglove, snapdragon, and calceolaria. Certain figworts live partially as parasites on other plants. The drug *digitalis,* used for heart ailments, comes from a kind of foxglove. Scrophularia, from which the family is named, is a medicinal figwort. People at one time believed that it would cure scrofula (see **Scrofula**).

Related articles in *World Book* include:

Beardtongue	Mullein
Digitalis	Slipperwort
Foxglove	Snapdragon
Indian paintbrush	Toadflax
Monkey flower	

Fiji is a country in the South Pacific Ocean. It is made up of more than 800 scattered islands. About 100 of its islands are permanently inhabited. Fiji has a total land area of 18,274 square kilometres. The Island of Viti Levu (Big Fiji) covers about half this area, and Vanua Levu (Big Land) occupies about a third. Many of the other islands of Fiji are merely piles of sand on coral reefs. Fijians and Indians are the country's two main ethnic groups. Sugar accounts for about two-thirds of Fiji's exports. Other exports are coconut oil, gold, and ginger.

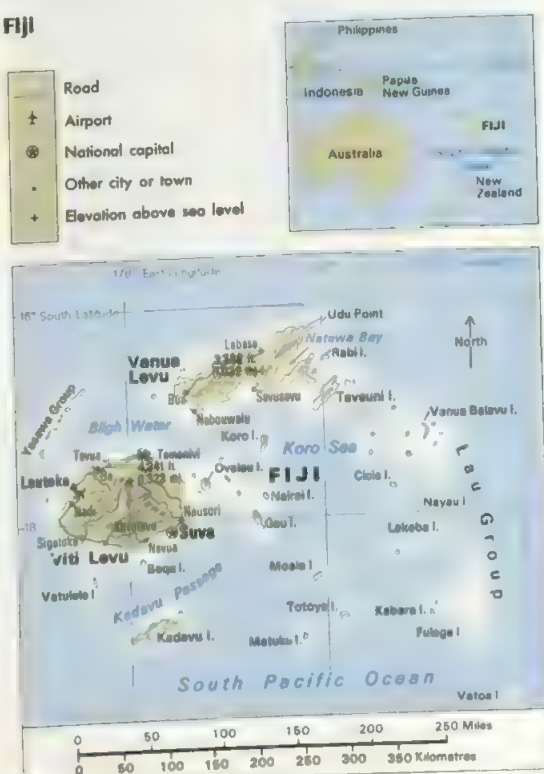
Suva, Fiji's capital, is on Viti Levu, the largest island. Suva is the largest city in the South Pacific, and has a population of about 65,000. There has been a strong growth outside the city boundaries, and the population of Greater Suva has reached more than 100,000.

For Fiji's total population, see the *Facts in brief* table with this article. About 48 per cent of the people are native Fijians of chiefly Melanesian descent. About 46 per cent are descendants of labourers imported from India. The remainder—Fiji's "general" population group—have Chinese, European, Micronesian, or Polynesian ancestry. Fiji became independent in 1970 after being a crown colony of the United Kingdom (UK) since 1874.

Government

In 1970, Fiji became an independent country within the Commonwealth of Nations. Both Queen Elizabeth II of the UK, as head of state, and a Fijian governor general, her representative, attracted fierce loyalty from all sections of the population. Fiji was expelled from the Commonwealth and became a republic following two military coups, in May and September 1987.

Fiji



National government. Fiji has a prime minister, who is head of the government. The prime minister selects a cabinet to help carry out government functions. Fiji also has a president, who is head of state. He is appointed to a five-year term by the Great Council of Chiefs, a traditional body of Fijian chiefs. The president appoints the prime minister. Fiji's parliament consists of a 70-member House of Representatives and a 34-member Senate.

Local government. Within the national system of government, the Fijians have their own administrative system, based on 14 provinces, each with an elected council. A *Roko Tui* serves as executive head of each council. The provincial councils deal with matters affecting Fijians in the provinces, and send delegates to meetings of the Great Council of Chiefs. This body discusses national legislation affecting Fijians and is the keeper of Fijian tradition.

Legal system. The Court of Appeal, the Supreme Court, and magistrates' courts administer justice. The legal system of the UK, with local modifications, is followed. The police force numbers 1,400.

Health services. Fiji is free of malaria and is unusually healthy for a tropical country. Medical and dental treatment can be obtained at low cost from government hospitals and clinics.

People

Population and ancestry. Fijians are a dark, frizzy-haired Melanesian people. Many of them, particularly those in the eastern islands, have some Polynesian blood. More than 80 out of every 100 belong to the Methodist Church. Most others are Catholic. In general, the Fijians live in villages. But more and more have settled in the towns in recent years. The practice of *kerekere* (helping one another) is an essential feature of Fijian life, and ceremony is important. The drinking of kava, a fermented drink called *yaqona* in Fiji, figures prominently in traditional ceremonies (see **Kava**).

Fijians own four-fifths of their country's land. Ownership is vested in each *mataqali,* or clan. Clan members share the rent when land is leased out. Leasing and administration of all Fijian-owned land is controlled by a Native Land Trust Board.

Indians in Fiji are mainly descended from labourers, who, between 1879 and 1916, were imported from India to work on the sugar plantations, and who chose to remain in the country. Most Indians still live in the sugar areas as tenant farmers or labourers. But increasing numbers live in Suva. The towns of Lautoka (23,000), Nadi (7,000), Ba (6,000), and Nausori (5,000) are almost entirely Indian. Most of Fiji's small businesses, and an increasing number of larger ones, are run by Indians. Indians also hold many of the country's clerical jobs and have a leading place in the professions. About 80 out of every 100 Indians are Hindus. Most of the rest are Muslims. A few are Christians. Marriages between Indians and Fijians are few. The two groups maintained good day-to-day relationships for many years, despite deep-seated tensions caused by the larger number of Indians and by difficulties over land.

Many Fijians fear that if their land is leased to the Indians for long terms they may not get it back. The Indians, for their part, feel insecure with short-term leases, and are reluctant to improve leased land unless they can obtain it for a worthwhile period. These fears, however, have been reduced in recent years through landlord and tenant legislation. The Agricultural Landlord and Tenant Act, in effect since 1967, aims to overcome the apprehensions of both groups. Despite their difficulties, some of Fiji's wealthiest citizens are Indians. They own much of the country's limited amount of freehold land.

Europeans and Chinese have declined in numbers, now numbering only 9,500, with slightly more Europeans than Chinese. Most of the Europeans are Australians and New Zealanders. They work in tourism, and as teachers and government advisers. The Chinese are mainly shopkeepers and technicians.

Part Europeans and other Pacific Islanders number about 25,000. They are employed in industry, on ships, and in skilled work in agriculture and mining. Many part Europeans work in government, commercial offices, and tourism. Most of the other Pacific Islanders are Tongans and Rotumans.

Language. English is the official language of Fiji and is used in the schools. But the country also has two other main languages, Fijian and Hindi. The Fijian language is related to the languages of Polynesia. Some letters are pronounced differently in Fijian. The Fijian *b* sounds like the *mb* in amber; *c,* like *th* in thy; *d,* like *nd; g,* like the *ng* in hang; and *q,* like the *ng* in Congo. The name of Cakobau, a famous Fiji chief, is pronounced *thakombau;* the town Nadi is pronounced *nandi.* Some books about Fiji, printed for use outside the country, use phonetic spellings.

Education. More than 123,000 children are enrolled in Fiji's primary schools and 43,000 at secondary schools. About 3,800 older students attend technical, vocational, and teacher-training schools. Of the 852 schools, only 29 are run by the government. Local committees and church bodies maintain the others and the government subsidises them. Nongovernment schools tend to segregate Fiji's children both by ethnic background and by religion at an early age. Primary education is free up to age 12. Some secondary education is free. The University of the South Pacific, in Suva, has schools of education, natural resources, and social and economic development. It has about 2,000 students from all over the Pacific. Degree and diploma courses in

Facts in brief about Fiji

Capital: Suva.
Official language: English.
Area: 18,272 km². *Greatest distances*—north-south, 586 km; east-west, 538 km. *Coastline*—1,489 km.
Elevation: *Highest*—Mount Tomanivi, on Viti Levu, 1,323 m above sea level. *Lowest*—sea level.
Population: *Estimated 1996 population*—769,000; density, 44 people per km²; distribution, 61 per cent rural, 39 per cent urban. *1986 census*—715,375. *Estimated 2001 population*—808,000.
Chief products: *Agriculture*—coconuts, forest products, sugar. *Manufacturing*—beer, cement, cigarettes. *Mining*—gold.
National Anthem: *God Bless Fiji.*
Flag: The British Union Jack appears in the upper left on a light blue field. On the right is the shield from Fiji's coat of arms with a British lion, a dove, coconut palms, and such agricultural products as bananas and sugar cane. Adopted on Oct. 10, 1970. See **Flag** (colour picture: Flags of Asia and the Pacific).
Money: *Currency unit*—Fiji dollar. One dollar = 100 cents.

Suva is the capital and largest city of Fiji. The city has many modern shops and offices along its canal.

agriculture are offered through the Fiji College of Agriculture and in medicine through the Fiji School of Medicine.

Land and climate

Land regions. Fiji has a land area of 18,272 square kilometres. Two main islands, Viti Levu (10,386 square kilometres) and Vanua Levu (5,535 square kilometres), make up most of this area. Other islands include Taveuni (435 square kilometres) and Kadavu (409 square kilometres). The island of Rotuma, 386 kilometres northwest of Vanua Levu, although geographically separate, is part of the republic. Fiji's main islands are mountainous and of volcanic origin. They are surrounded by dangerous coral reefs. Islets of sand and mud washed down from the rivers over the centuries have formed on some of the reefs. The highest point in the group, Mount Tomanivi, is 1,323 metres. Almost 30 other peaks are over 910 metres.

Climate. Fiji lies in the path of the southeastern trade winds, which, most of the year, bring heavy rain to eastern and southern coasts. February and March are wettest. Winter is driest. Suva's annual rainfall is more than 300 centimetres. Lautoka, in the northwest of the same island, has only about 180 centimetres. Suva's temperatures range from about 30° C in February to about 20° C in August.

Economy

Agriculture. Sugar, Fiji's main export crop, is grown along the coastal lowlands of the dry northwestern side of Viti Levu and around Labasa on the northern side of Vanua Levu. More than 22,000 Indian tenant farmers produce the cane on small holdings. They sell it to the Fiji Sugar Corporation Limited. The cane is processed at mills at Lautoka, Labasa, Ba, and Penang. These mills employ nearly 4,000 people. About 6,000 others are employed seasonally in sugar-harvesting.

Coconuts, the second most important crop, are grown mainly on the southern side of Vanua Levu and in the outer islands. *Copra* (dried coconut flesh) is shipped to Suva to be crushed for oil. Hurricanes, droughts, aging trees, and low prices have depressed the coconut industry in recent years. Promising new exports include ginger and cocoa. Pineapples, rice, and tobacco are grown for local use. Systematic planting of pine trees is laying the foundation for an expanded timber industry.

Mining. Gold is produced from the Emperor Mine at Vatukoula on Viti Levu. There are copper deposits about 40 kilometres north of Suva.

Industry. Fiji produces manufactured goods chiefly for local consumption and export to other Pacific islands. These goods include agricultural equipment, building materials, containers, plastics, furniture, food, beer, cigarettes, clothing, soap, and matches.

Trade. Sugar is sold to New Zealand, Malaysia, China, the UK, and the United States. The sales to the UK

Police in Fiji number more than 1,000. This policeman, in a traditional uniform, directs traffic in Suva's market area.

Fijian houses outside the main towns are *bures*—cottages made with wooden frames and thatched with dried coconut palm or pandanus leaves.

are made through the European Community under agreements that provide for an annually negotiated price. In recent years, this has been substantially above the world market price. Australia supplies about 29 per cent of Fiji's imports. Japan is next with 16 per cent. New Zealand and the UK contribute 12 to 13 per cent each.

Transportation and communication. Nadi and Suva have international airports. Domestic airports link most of the larger islands. Cruise and cargo ships call at Suva and Lautoka. A road encircles Viti Levu, and many other islands of the group are being increasingly provided with good roads. Television was introduced in 1987. Two English language newspapers, the *Fiji Times* and the *Fiji Sun,* are published daily in Suva.

History

Archaeological research has shown that people arrived in Fiji more than 3,000 years ago. The first settlers were probably Melanesians from the islands to the west. Some of their descendants later mingled with Polynesian immigrants from the east, and there has been close contact with Tonga in historical times.

Abel Tasman sighted the eastern islands in 1643. Captain James Cook, an English navigator and explorer, visited Vatoa, one of the southern islands, in 1774. The first European to see the main islands was William Bligh. He passed through the islands in 1789, during his open-boat voyage to Timor after the *Bounty* mutiny. Europeans in search of sandalwood began visiting Fiji in the early 1800's. Others came later for *bêche-de-mer* (a sea slug eaten in Asia), and whalers put in for provisions.

The first Christian missionaries made little headway until they settled near the small island of Bau, off the southeastern corner of Viti Levu, in 1839. Bau was the headquarters of a chief called *Cakobau,* who had extended his influence over the coastal villages of Viti Levu and to many of the islands to the east. By 1850, he was commonly called *Tui Viti* (King of Fiji). But some of his conquered people later revolted against him. This led him to embrace Christianity. Much of the fighting ceased and cannibalism was abandoned.

Cakobau faced debts arising from claims by a former American consul, John B. Williams. When W. T. Pritchard arrived in Fiji as the first UK consul in 1858, Cakobau offered to cede his islands to the UK if the UK would pay his debts. Pritchard went to London to put Cakobau's offer before the UK government. The UK sent two investigators to look into the situation.

Rumours that Fiji would become a colony of the UK brought many Europeans there from Australia and New Zealand to settle. These settlers made various attempts to establish a stable government under Cakobau's authority. But all ended in failure. Finally, on Oct. 10, 1874, the UK accepted a second offer of cession. Fiji became a crown colony, with its capital at Levuka. The capital was moved to Suva in 1882.

When the first UK governor, Sir Arthur Gordon, arrived, the economy was stagnant. Gordon thought that growing sugar was the best way to revive the economy but feared that large-scale employment of Fijians as plantation labourers would disrupt their traditional way of life. He imported labourers from India to work on the sugar plantations. About 2,000 labourers arrived each year, and many stayed after their contracts expired.

By 1946, the Indians outnumbered the Fijians. Sugar had become Fiji's principal industry throughout its 96

years as a UK colony. The industry was controlled by the Colonial Sugar Refining Company of Australia until two years after Fiji became independent on Oct. 10, 1970. The Fiji government, through its Fiji Sugar Corporation Limited, then took charge of the industry.

Ratu Sir Kamisese Mara, a Fijian chief, led a multiracial but Fijian-dominated government until 1987. In April 1987, an Indian-backed coalition won a majority in parliament. The coalition leader, Timoci Bavadra, a Fijian, replaced Mara as prime minister. Bavadra appointed a multiracially balanced Cabinet.

Many Fijians resented Bavadra's action because they wanted to keep political power only in Fijian hands. Military officers led by Colonel Sitiveni Rabuka overthrew Bavadra's government. Rabuka abolished the Constitution, named himself head of state and government, and declared the right of Fijians to govern the nation. In December 1987, Rabuka appointed a president and returned Fiji to civilian rule. In 1990, Fiji adopted a new Constitution designed to ensure that political power remains with the Fijians. Elections for the House of Representatives were held in 1992, and Rabuka became prime minister. He was reelected in 1994.

See also **Mara, Ratu Sir Kamisese; Suva.**

Filament. See **Flower** (The stamens).

Filament. See **Electric light.**

Filaria is a long threadlike roundworm that lives as a parasite in the bodies of human beings and animals. Filariae are commonly found in tropical and subtropical countries. The male worm is shorter than the female and it has a curved tail.

The *larvae* (young worms) are born alive. They can be seen in the blood near the body surface of the *host* (the animal in which the larvae live). When a bloodsucking fly or mosquito bites an infected person, it takes up the larvae with the blood. The larvae develop in the mosquito's or fly's head near the mouth. Then when the insect bites another animal, the larvae enter the wound and infect a new host.

Wuchereria bancrofti is a filaria harmful to human beings. It is found in Africa, South America, and the Far East. The adult worms live in the *lymph,* a body fluid (see **Lymphatic system**). When the worms block the flow of lymph, a disease called *elephantiasis* results. This disease is characterized by severe swelling of the limbs, usually the legs (see **Elephantiasis**). *Wuchereria bancrofti* can be eliminated by controlling the mosquitoes that carry the larvae. Other kinds of filariae infect such animals as cattle and dogs.

Filaria, shown here under a microscope, is a parasite common in tropical countries.

Scientific classification. Filariae are members of the roundworm phylum, Nematoda.

See also **Manson, Sir Patrick; Roundworm.**

Filbert is the name for both the nut and the plant of a group of trees and shrubs closely related to the birches. The nuts are also called *hazelnuts* and *cobnuts* (see **Hazel**). Some filbert trees grow 18 metres tall. Others are shrubs that normally grow from about 0.5 to 10 metres high. Filberts are native to North America, Europe, and Asia. They thrive in orchards in the Pacific Northwest of the United States and in southern Europe. Larger nuts grow on the cultivated trees than on the wild ones. The seeds can be eaten either roasted or raw.

The nuts form in compact clusters, with each nut encased within its own husk. The nuts have smooth, hard, but thin and brittle shells. The kernels are single.

Scientific classification. Filberts belong to the birch family, Betulaceae. Most cultivated varieties are *Corylus maxima.*

Filibustering is the practice by which a minority in a legislature uses extended debate to block or delay action on a proposed bill. Members of the minority make long speeches, demand roll calls, propose useless motions, and use other delaying tactics. If they can keep the bill from coming to a vote, they can defeat it even if the majority is in favour of it.

The United States Senate has a tradition of unlimited debate. A senator who holds the floor may speak without interruption. The Senate can end a filibuster by reaching an informal compromise with the filibusterers, or by invoking the *cloture rule,* to end debate. This rule was adopted in 1917 and strengthened in 1979 and 1986. Under the cloture rule, a vote of 60 senators, three-fifths of the Senate membership, can limit each senator to one hour of debate on most bills. The rule also prevents senators from introducing large numbers of amendments. Final action on a bill is required within 30 hours after the cloture rule has been invoked. However, filibusters on proposed changes in the Senate rules can be stopped only by a two-thirds majority of the members who are present and voting.

From 1917 to 1962, Southerners opposed to civil rights bills staged most filibusters. During these years, cloture was invoked only four times. Today, filibusters and clotures occur routinely on a wide range of bills.

A filibuster against the civil rights bill of 1964 lasted 75 days, the longest since the cloture rule was adopted. Several senators have filibustered for half a day or more.

The word *filibuster* originally meant *pirate.* Some members of Congress charged that the use of delaying tactics to block the will of the majority was like *filibustering* (piracy).

Filipinos. See **Philippines** (introduction; Population and ancestry); **Races, Human** (table: Geographical races [Asian]).

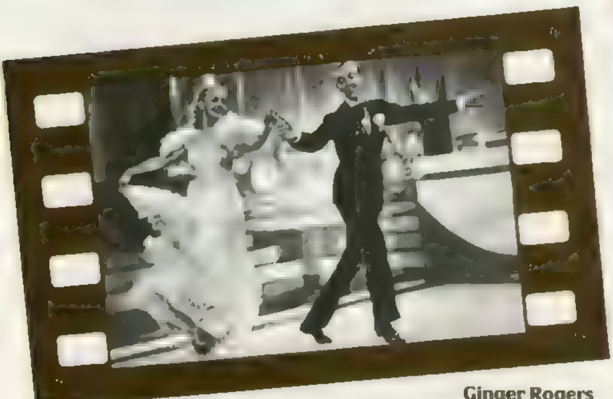
Fillmore, Millard (1800-1874), was president of the United States from 1850 to 1853. A Whig, he was elected vice president in 1848. He became president on July 10, 1850, following the death of President Zachary Taylor.

As president, Fillmore approved the Compromise of 1850, a series of laws designed to settle the strife between opponents of slavery in the North and slaveowners in the South. For example, the compromise abolished the slave trade in Washington, D.C., on the one hand, but it established a stricter fugitive slave law on the other. Fillmore faithfully enforced the compromise, including its provision for the return of runaway slaves. His policy lost him the support of most Northerners, and he was not nominated for president in 1852. Fillmore was born in Locke, New York.

Film. See **Film industry** (The film); **Photography** (Developing and printing; pictures).

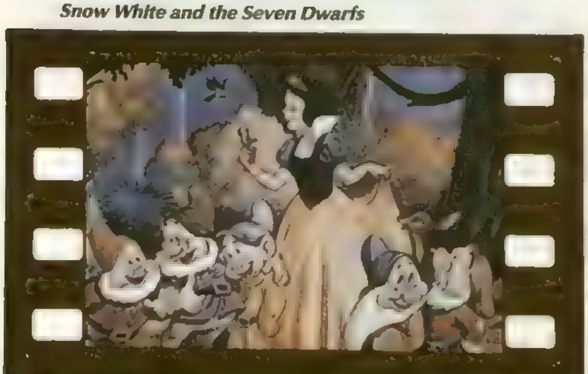
George C. Scott in *Patton*

Charlie Chaplin in *Easy Street*



Ginger Rogers
and Fred Astaire in *Swing Time*

Snow White and the Seven Dwarfs



Boris Karloff in *Frankenstein*

Film industry

Film industry is the art and business of making films, also known as movies, motion pictures, or cinema. A moving film is a series of images recorded on film or tape that appear to move when played through a film projector or a videotape player. Film is one of the most popular forms of art and entertainment throughout the world. It is also a major source of information.

Films can introduce people to new ideas and help them to explore social issues. Students learn from educational films. Industries use film and video to train employees and to advertise their products. Governments use film to inform and influence their own citizens and people in other countries. Every week, millions of people go to the cinema. Many millions more watch films that are broadcast on television or are played back on a videotape player.

But films are much more than just entertainment and a source of information. They are also a major art form, as are, for example, paintings and theatrical plays. Artists express themselves by using paint and playwrights by using words. Filmmakers express their ideas through a motion-picture camera. By using the camera in different ways, the filmmaker can express different points of view. A filmmaker may film scenes for a picture in a desert, on a mountain, and in a large city. Filmmakers can also film scenes from different angles. Later, through a process called *editing*, they can select the angle that most effectively expresses a dramatic point. Through editing, filmmakers can also show events happening at the same time in different places.

Films have become a gigantic industry. A typical feature-length film costs several million U.S. dollars to make and requires the skills of hundreds of workers. Highly technical devices, including cameras, sound-recording equipment, and projectors, are needed to make and show films. In fact, films could not exist without many of the scientific and technical discoveries made since the late 1800's. For this reason, films have been called the art form of the 20th century.

We can enjoy many forms of art and entertainment by ourselves. We can enjoy reading a story or looking at a painting alone. But we usually enjoy a film most when we watch it as part of an audience. An exciting scene increases in suspense when we feel the tension sweeping

Clark Gable and Vivien Leigh in *Gone with the Wind*

John Barrymore and Greta Garbo in *Grand Hotel*

through a large group of viewers. A film usually makes less of an impact if we see it in a nearly empty cinema or alone at home.

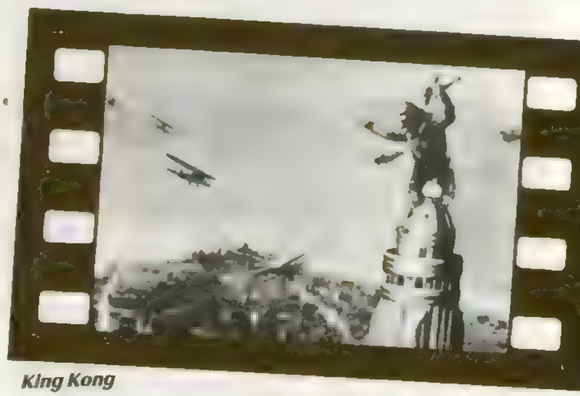
Films have a brief history, compared to such art forms as music and painting. Films date back only to the late 1800's. By the early 1900's, filmmakers had already developed distinctive artistic theories and techniques. However, films received little scholarly attention until the 1960's. Since then, thousands of books have been published about every aspect of filmmaking and film history. Universities and colleges offer degrees in various aspects of the film industry, and many more offer film courses.

In education, films are used especially as teaching aids. Teachers use such films in classes on geography, history, mathematics, and the physical and social sciences. Films use slow motion, animation, and other special techniques to demonstrate processes that otherwise could not be seen or studied thoroughly. For example, a film can speed up the formation of crystals so the audience can study this process.

Television stations use films to inform as well as to entertain their viewers. TV channels frequently present *documentaries.* A documentary is a nonfiction film that tries to present factual information in a dramatic and entertaining way. Documentaries deal with a variety of subjects, such as environmental pollution and the history of different cultures. Made-for-TV movies may deal with sensitive social issues within the framework of an entertainment film.

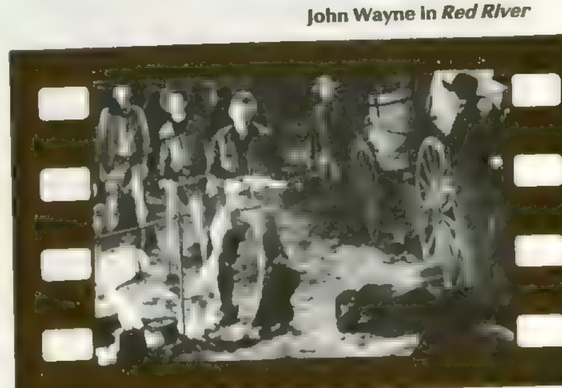
Millions of people enjoy making their own films with small cine or video cameras. Most of these cameras also record sound as they are filming. Home movies began to develop as a hobby during the 1920's, following the invention of low-cost film that could be used in small cameras. The popularity of home movies has increased over the years with the improvement in cameras and projectors, the introduction of colour and sound film, and the development of home video cassette recorders, or VCRs, that play back on TV sets.

This article deals mainly with feature-length films made for showing in cinemas and on videocassettes and television. For information on home movies, see **Photography** (Making home movies).



King Kong

John Wayne in *Red River*



2001: A Space Odyssey

How films are made

Shooting the picture is actually one of the later stages in making a film. First comes a great deal of planning and development. The film above is being shot on a *sound stage*—a large soundproof building especially designed for filmmaking.

Making a feature film calls for a special blend of art and business skills. A Hollywood production may take less than six months or more than two years to create. It can cost less than 250,000 U.S. dollars or more than 50 million U.S. dollars. On a large-budget film, several hundred people will be employed.

Although the film cast and crew may include hundreds of members, the people who perform two key functions remain at the centre of the filmmaking process: the *producers* and the *director*. The producers are the chief business and legal managers of the film. Usually, one or more *executive producers* from the film company supervise the work of the producer of a specific film. By choosing the director and other key members of the creative team, and by supervising the budget, the producers exert great influence over the creative part of the film production.

The director is responsible for guiding the creative efforts of the screenwriters, cast, and crew. By influencing the film's shooting schedule and the equipment and personnel needs of the film, the director plays a major role in shaping the budget.

Each film presents a different set of problems for the producers and director. Some films call for extensive travel to distant locations. Others call for complicated special effects. Some need elaborate sets or an intimate and subtle acting style. Regardless of the particular challenges, each film will pass through five stages to reach its audience. These stages occasionally overlap, but they occur in the following order: (1) development, (2) pre-production, (3) production, (4) post-production, and (5) distribution. This section describes the first four stages. The fifth stage—distribution—is discussed in the section *The film industry*.

Before the late 1940's, almost all films were produced by major studios. Today, most films are made by independent film producers. The following section describes chiefly how a motion picture is made by an independent producer. However, the key personnel and many of the steps also apply to films made by the major studios. For information on the "studio era," see the *History* section.

Development

Developing the story. All feature films begin with an idea for a story. The idea can come from a newspaper article, from someone's imagination, or from an existing book or play. The idea may be as complicated as a 30-page outline or as simple as a single sentence. No one person is responsible for finding an interesting source for a film story. Movie ideas come from screenwriters, producers, directors, actors and actresses, agents, and friends of the filmmaker.

After a good idea has been identified, the producer or director must find a screenwriter with the ability and sensitivity to turn that idea into a story that will work as a film. Once commissioned, the screenwriter works closely with the project's originator to develop the characters and to construct the story based on the original idea. The screenwriter's job is to create the document that will serve as the blueprint for producing the film. This document is the *screenplay*.

The script contains the dialogue, a description of the action, and the camera angles for each scene. The script supervisor records the director's instructions on the script, *above.*

The director works to achieve a desired result in a scene. The director above explains his ideas about a future shot to an actress. Below, he listens to a suggestion from a technician.

When looking for a *property* (story) to film, producers also review scripts prepared by screenwriters working on "spec." "Spec" means that the screenwriter has not been contracted—or even informally asked—to write a script based on someone else's idea. Instead, the writer is speculating that his or her own idea will be sold to a producer or studio.

A writer working on spec sends an original script to an agent who will market it. The agent shows the script to producers and studio executives who may be interested in purchasing and producing it. If they are interested, they can purchase the script outright or—for a reduced fee—they can *option* it. By taking an option on a script, producers acquire the exclusive rights to the script for a limited time. During that time, they explore the possibility of producing the script. If they decide to produce it, they then buy the script. If they want more time to decide, they can renew the option. If the option is not renewed, the screenwriter keeps the option fee and has the right to sell the script to another producer.

Acquiring financing. After obtaining a property, most independent producers must secure financial backing for the project. As a first step, they usually try to interest a successful director or a recognized actor or actress in the film. Associating a proven director or star with the project helps assure investors that the film will have box-office appeal. Choosing the director and leading performer is one of the most important preliminary steps in the production of a film—not only because it helps in obtaining financing, but also because each star-director-producer team will interpret a script differently.

In another major step before approaching potential investors, the producers prepare an estimated budget and a shooting schedule. They consider the expected size of the film's audience, the amount of money realistically required to create the film, the time needed to make the film, and the amount of money they can expect to raise from investors.

After the producers are satisfied with the estimated budget and shooting schedule, they put together the film's "package." The package consists of the budget, script, shooting schedule, and key creative people who will make the film. Based on the package, the producers seek funds from banks, studios, or private investors. The money will be raised if the creative team's experience and "name recognition" value are strong and the budget seems low enough for the film to make a profit. In some cases, the package will be so strong that the producers will also be able to sell the project to a distributor at this stage. Once the funds are secured, the actual planning of the production can begin.

Preproduction

During the preproduction stage, the producers, the director, and other key crew members create a detailed plan of action for turning the script into a film. This involves planning for all the creative decisions, personnel choices, equipment, and material necessary to make the film. The goal is to anticipate and solve all problems likely to be encountered in producing the film.

The preproduction period can take as little as two weeks to six months or more. By the end of this period, the crew is a well-organized group with a common goal. They understand the deadlines they face to complete the film, and they have all the major materials ready so they can execute their plan smoothly.

The preproduction period is the beginning of intense collaboration among the members of the production team. At the centre of these collaborations are the producers and the director. They develop and carry to the members of the crew their overall vision of the film. Through a series of meetings and discussions with the cast and crew, they decide upon the specific interpretations of the look and sound of the script.

Reviewing the script. All phases of preproduction start with a careful reading and analysis of the script. The director examines the script to understand the story and to develop a vision of the most effective way to translate the script into film and sound images. Suggestions from members of the creative team often lead to further revisions of the script. The director also develops ideas on casting, costuming, set design, photography, and editing.

Assembling the production team. Working closely with the producers, the director hires a crew. The director will try to choose people who, because of their experience and understanding of filmmaking, will develop and enhance the director's idea of the film.

The production manager is one of the key positions in the team. The production manager develops the actual budget and shooting schedule. Working under the producers, the production manager will supervise the production and authorize all expenditure.

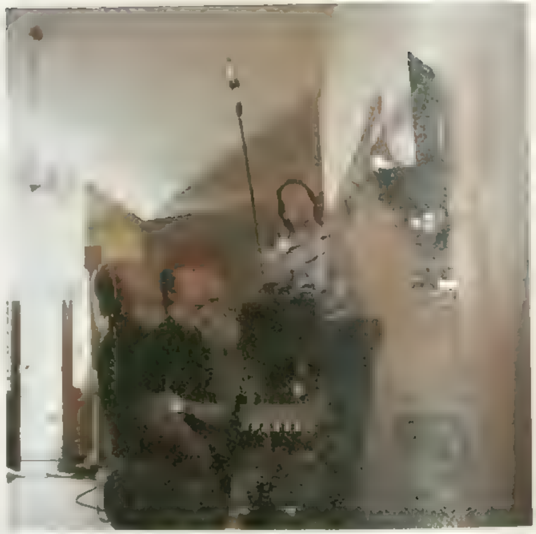
The director of photography, or *cinematographer,* is responsible to the director for achieving the best possible visual look for the film. The director of photography supervises the camera crew, and designs and executes the lighting pattern of the film.

The art director is responsible for designing and creating the sets. He or she makes blueprints and sometimes models of the sets. Once the designs are approved, the art director oversees their construction.

The costume designers and their crew are responsible for designing and making the costumes. They may also purchase costumes for the production. In preparing their work, the costume designers must consider the work of the director of photography and the art director. The colours and patterns used on walls and in the lighting will affect the work of the costume designers. They can create a feeling of harmony by designing costumes that blend with the background. If the costumes clash with the sets, the audience can be subtly informed that the characters are out of place with their surroundings.

Through a series of meetings, the director and the heads of the various production departments discuss the script and how to translate it into props, costumes, hairstyles, colour, lighting, compositions, and camera movements. This close collaboration and exchange of ideas will lead to the planning of the film's design.

During the preproduction period, a crucial decision faces the producers, director, director of photography, and art director. They must decide whether to film each scene on a *sound stage*—an artificial set constructed in a building—or on *location*—a real place that resembles the one depicted in the story. This decision affects both the look and the budget of the film. Most films combine both location and sound stage filming. The advantages and disadvantages of each technique are discussed under *Production.*



The director of photography, *right,* tries to create the best look for the movie. The director of photography supervises the camera crew and designs and executes the film's lighting.

Developing the shooting schedule is the job of the production manager. Knowing how the director wants the film to look gives the production manager a feeling for how long and how difficult the filming will be. A number of variables help determine how many days the crew will need to shoot the film. These variables include travel to distant locations, construction of elaborate sets or lighting setups, and planning long and complex camera movements. By knowing how many days will be needed, the production manager can plan a schedule for shooting the film.

Makeup artists apply cosmetics to help an actress's colouring look natural under the bright lights needed for filming.

The costume designer creates the film's costume designs, oversees their production, and makes sure they suit the actors and actresses.

To save time and money, the production manager plans a schedule in which most of the scenes will be shot in a different order from that in which they appear in the script. For example, if scenes one, five, and nine all take place in the same living room, it will save time and expense to shoot them in one session. This way, the crew only has to set up the lights once and the production manager only has to organize the materials needed on that set once. If the scenes were shot in the order in which they appear in the script, the crew would have to set up the same equipment three separate times.

Preparing the final budget. With the shooting schedule prepared, the production manager can begin laying out the actual cost of the film. The production manager must stay within the guidelines of the estimated budget and the amount of money raised from the investors. He or she can specify what equipment to use and how much it will cost, and can decide how much time will be needed to edit the film. A shorter time will be required if the director plans the film carefully in the preproduction stage. More time will be needed if the director *improvises* on the set. Improvising means that, as the film is being shot, the director works to discover the best way to play a dramatic moment or find the most appropriate camera position.

The production manager makes a final budget after reviewing the script for its costume, location, and acting needs, and after identifying the necessary equipment and size of the crew. The final budget includes *above the line* costs and *below the line* costs. The above the line costs are the salaries for key actors and actresses, the fees for the producers and director, and the purchase of the script and other creative fees. Below the line costs include crew salaries, equipment rentals, insurance costs, film and sound stock purchases, and rent for editing rooms. The producers and the director then review the budget and shooting schedule. They may request adjustments to figures they feel are unrealistic.

During the preproduction period, the producers and production manager refine the budget. They plan how the budget will be spent day by day until the film is completed and ready for distribution. The production manager and the assistant director work with the heads of the various departments so they can plan their work to meet the needs of the schedule and the budget.

Assembling the cast. As the budget and shooting schedule are being completed, the director works with the producers and casting director to complete the cast. The casting director's job is to screen the applicants. He or she sometimes considers hundreds of actors and actresses for each major role in a film. Through a series of auditions and interviews, the selection is narrowed down to a few candidates for each role. At an audition, a

Preparing to shoot a scene, the various technicians set up their lights while another crew places the sound gear in position to record the action on audiotape. Adjustments in equipment positions may be made to film different versions of a single shot.

performer may be asked to read from the script or to act in a scene previously prepared. The director and producers select the final cast from the pool of performers identified by the casting director. Actors and actresses are chosen for their talent and their ability to blend with other performers to create a team performance. The actors and actresses are also selected for how appropriate they are for the role, based on their appearance, temperament, and the director's interpretation of the role.

Holding rehearsals. If time permits and the performers are available, rehearsals take place before shooting. During rehearsals, the director and the cast explore the characters and script together. They read through the script and discuss the story and the role each character plays in it. They then act out the scenes and rework them to fit their talents and interpretations. They may use improvisation to explore each character and the possible ways to play a scene.

Not all directors hold preproduction rehearsals. Some only discuss the story and characters with performers at this time. They prefer to wait until the actors and actresses are actually on the set to rehearse each scene. Performers with small parts usually meet the director for the first time the day their scene is shot.

Building a set usually takes place on a sound stage. The art director is responsible for designing the sets. After the designs are approved, the art director oversees their actual construction.

Production

During the preproduction period, the filmmakers imagine the film they want to make. They gather the people and materials needed to realize their idea. During the production period, the film-as-imagined is brought to life and recorded on film and audiotape. The creative work of the preproduction period is continued and extended. However, instead of working with words or drawings or budgets on paper, the filmmakers work with actors and actresses and the materials of real life.

Filming on a sound stage. A sound stage is a hangarlike building in which sets can be built. Shooting on a sound stage enables the production team to design and build the sets to exact specifications. It allows them to place the camera exactly where they desire, and to create precise scale and details in their sets. Achieving the desired lighting is easier because each stage has a grid of pipes suspended from the ceiling. This grid allows the director of photography to hang each lighting unit with precision. The stage is enclosed, which eliminates noise and distractions from the outside world. Working on a stage saves time when setting up, and avoids moving the film's company from place to place because everything is shot right on the sets.

The disadvantage of filming on the sound stage is the extra cost. Constructing sets is much like building a house. A designer must make architectural plans of the set. Carpenters must build it and the set must be painted and furnished.

Filming on location. The advantage of shooting on location is that the set, for example, a city street, a mountain, or a harbour, already exists. Additions can be made to the location to create the appropriate look. If, for instance, the scene needs a driveway but there is none at the site, a false driveway can be added.

The main disadvantage of shooting on location comes from the fact that locations were not designed for filmmaking. The filmmakers may not have the room to spread out their equipment and freely move the camera. They must bring in generators to supply enough electricity for their lights. The location is more difficult to protect from outside intrusions, such as passers-by, noise from traffic and aeroplanes, and changes in light throughout the day. The cast and crew must be transported to the locations, which may be in distant parts of the world. The personnel must be fed and housed. However, the success of many films comes from the authentic look and feel of the location, which outweigh the disadvantages.

Some filmmakers shoot outdoor scenes on a *back lot,* an open air area on studio property. A back lot set is a re-creation of an exterior, such as a city street. Filming on a back lot saves time and money that would be consumed shooting on location. However, the results may be less authentic-looking than location shooting.

Preparing to shoot. The location or the set on the sound stage must be carefully prepared before the camera can interpret the action. The shooting day usually starts very early. Trucks begin arriving with lights, props, and camera and sound equipment at 6 or 7 a.m. The *set decorator* arranges the props. Hairdressers and makeup artists arrive just before the performers. The actors and actresses often spend at least an hour having their hair and makeup prepared for each day's shooting. The craft services crew puts out refreshments for the crew as they set up. The director and assistants review the schedule for that day's work. The director of photography directs electricians called *gaffers* in setting up the lights.

The set must be lit brightly enough for an image to be made on film. Lighting a scene is one of the most time-consuming and important aspects of film production. Lighting creates a mood or a tone for each scene. The lighting director or director of photography uses contrast as a major tool. Contrast is the relative brightness of a character or object against surrounding shadows

Filming on location provides a movie with realistic settings that might be difficult, as well as more costly, to create at a studio. But on-location shooting also has disadvantages. For example, personnel and equipment must be transported to the location, which can present problems in remote areas.

and darkened areas. A happier, more upbeat mood can be created by lowering the contrast and making the scene brighter. A scene filled with shadows and set off by a few small areas of bright light is usually more sombre. In a thriller, a threatening tone can be developed in a darker scene emphasizing heavily contrasting light. An audience sits in expectation, waiting for something or someone to jump out of the shadows.

As the lighting is being adjusted, the performers and director come to the set. They review their work from the rehearsal period, focusing on their characters' actions and reactions in the upcoming scene. For unlike live theatre, where the performer acts in a continuous time sequence, film requires a performer to work in fragments of scenes. Each shot in a film seldom covers more than a minute or two of the film's story, and, as explained earlier, the scenes themselves are shot out of order. Consequently, film performers must develop their characters without the help of continuity, and the actors and actresses must have a strong sense of the film's time sequence. Acting in fragments does have some advantages, however, over stage acting. In the movies, the performer can concentrate on the very short sequences of dialogue or movement that go into a given shot.

Shooting the film. After the lighting preparation is completed, the director and performers go onto the set and rehearse in front of the camera operator and a technician called the *sound mixer.* The director works with actors and actresses to polish their performances. In addition, the camera operator checks to be sure that the photography will be satisfactory, and the sound mixer makes certain that a good clear audio recording can be made. Then the shot is recorded on film and audiotape. Usually, there are several *takes* (versions) of each shot. The director may call for a retake to improve upon a performance or to ask for a different interpretation of the scene. The performer may want to try a new approach, or the camera operator may want to improve the framing of the shot or the camera movement.

Lighting is responsible for much of a scene's dramatic effect. In this shot from a horror film, the shadowy background contrasts with the brightly lit faces to heighten the tension.

Much of the shot's impact depends on the choice of camera lens and position, and on the *blocking* of actors and actresses. A long, or *telephoto,* lens makes a scene look flat. A *wide-angle* lens deepens space. Camera position influences how an audience understands a scene. For example, if a camera is placed so that it looks at a character through a fence or a set of bars, the audience will probably feel that the character is closed in, almost imprisoned.

Blocking refers to how the performers move during a scene. If a character moves toward the camera and grows large in the frame, he or she will take attention away from the other performers in the frame. If characters walk away from the camera, the audience will feel that the figures are isolated or vulnerable or less important, depending upon the preceding action and scenes.

A device called a *clapperboard* is used to keep track of the takes and shots—information that will be needed during the post-production stage. A clapperboard consists of a slate attached to two hinged boards. The slate is marked with the number of each scene and take. The clapperboard is photographed before each take, thus visually identifying the scene number and the take number. A member of the camera crew also says aloud the scene and take numbers, and then immediately claps the two boards together to make a sharp sound. The spoken information and clapping noise are recorded on the sound track, creating an audio record just as the slate preserves a visual record of the filming.

After each take, the director consults with the performers, the director of photography, and the camera operator. They decide on any adjustments that could improve the shot. Traditionally, they had to rely on their instincts to judge how the take would look on the film. Since the 1970's, however, many directors have used a *video assist* to help judge the takes as they are being shot. The video assist is a video recording system attached to the motion-picture camera. It records an image on videotape at the same time the camera is filming. The videotape can be examined immediately after shooting, an advantage over the camera film, which must first be processed in a laboratory. The video assist thus provides the filmmakers with a faster way to judge the work in each shot, allowing them to determine what improvements need to be made in the next take.

A clapperboard is a hinged board used to keep track of the takes, scenes, and other information during actual filming.

On a low-budget film, only three or four takes may be made from each camera setup. On a big-budget film, as many as 50 takes might be made. After the director is satisfied with a take, it is *printed*—that is, sent to the laboratory for processing. A copy called a *work print* is then made for the editing phase.

After all the takes of a shot have been made, the crew, supervised by the director of photography, sets up the lights and camera angle for the next shot. The performers go to their dressing rooms, or to their caravans if they are on location, to wait for the crew to complete its work. Meanwhile, the director talks to the designers about the next day's set. The director may also meet with the producers and production manager to discuss the schedule, budget, or other production-related matters. At the end of the day, if the work is on location and completed, the crew packs up the equipment and moves the company to the next location.

Postproduction

The production stage provides the raw materials from which the film will be constructed. This raw material consists of fragments of film and audiotape. The fragments record the characters, places, and events that make up the film's story and interpretation. Postproduction is the stage during which the raw material is edited into a film. Editing refers to the total process of putting a film together in a final form. In many ways, editing resembles the writing stage of filmmaking. But instead of constructing the story out of words, the editor and director select the best shots and dialogue. They use them to lay out the film's structure and to determine its moment-to-moment shape.

Throughout the process, the editors pay close attention to the rhythm and tempo of the film. They carefully choose where each shot begins and how it flows into the next shot. If necessary, the film can be reinterpreted during editing to take advantage of its strengths and to diminish its weaknesses.

Preliminary steps. The editing process begins after a sequence of important steps to prepare the *camera original* and the sound track for editing. The camera original is the film exposed during the production stage. First, the work print must be made by the film laboratories after the camera original has been processed. The work print is used during the editing to preserve the camera original from damage. The sound track must be copied onto a tape the same width as the film. Matching the size of the film and tape allows the editor to put the sound track and picture on the same machine while editing.

Next, the sound must be brought into *synchronous* relationship with the picture. This means the sound must be placed so it exactly matches the action in the picture. For example, when an actor speaks on the film, the audience should hear his voice at the same time. On the film, an assistant editor marks the clapperboard frame where the boards close and then marks the corresponding clapperboard sound on the sound track. Lining up this sound and the appropriate picture frame creates the synchronous relationship. The assistant editor has to find and establish this synchronous relationship for every shot in the film. After the film and sound

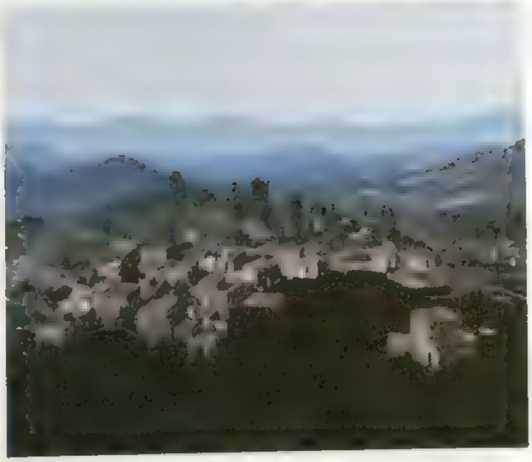
The editor operates a machine called the Steenbeck. The editor examines the film on the Steenbeck screen and selects the desired shots. The editor then organizes them to tell the film's story.

have been "synced up," the assistant editor makes a detailed written record of each shot. This written log enables the editors to keep track of the thousands of feet of exposed film.

The rushes. Next, the director and editor screen this raw, unedited footage, called *rushes,* or *dailies.* They discuss which shots to use and sketch out how the shots should be arranged. These screenings usually take place at the end of each day's shooting during production—an example of how the different stages of making a movie overlap. The editor, director, producers, and other crew members see the footage from scenes filmed the previous day. In this way, they can check on the quality of their work. If necessary, they can adjust their approach. They can reshoot a single shot or an entire scene before leaving a location. They can also create new scenes to fill in gaps in the story they did not realize existed. Most important, they can begin the actual editing process.

The rough and fine cuts. Based on the discussions with the director and producers, the editor begins to assemble the selected footage and put it in order. This preliminary version of the film is called the *rough cut.* It follows the order of the screenplay, using the shots selected by the director.

After the rough cut is completed, the editor screens it with the director. Based upon their response, different takes of shots may be used, and the order of scenes may be changed. Scenes that fail to add to the storytelling might be dropped. The editor makes these adjustments, which clarify and strengthen the story and refine it



Special effects create illusions. The top picture shows a painting on glass called a *matte* painting. The black area blocks out light. The middle picture shows a shot from a real set, also with a black area. At the bottom, the matte painting and the shot of the set—this time photographed with live actors—have been combined to create the finished scene.

closer to its final shape. This version is called the *fine cut.*

This cut is then screened and analysed with the producers. To get a fresh opinion, friends and fellow filmmakers not involved with the production are also invited. Adjustments are again made to improve the story and the filmmaking. The director continues to supervise cuts until he or she is satisfied, given the limitations of the budget and the post-production schedule. The producers or the studio can then take over and polish, revise, or completely restructure the film as they see fit.

Adding music and sound effects. During the editing, the composer and sound editor join the other filmmakers. Some composers want to be involved from the initial planning of the film to absorb its mood and to understand its development. Most composers, however, are brought in during or after the rough cut has been completed.

The composer and sound editor will screen the film with the director, identifying appropriate moments for sound effects and music. They discuss the kind of music the film calls for and the instruments that will be used in recording the music. Sometimes the discussions result in a scene being reedited. The director may decide that a passage of dialogue can be effectively replaced by music.

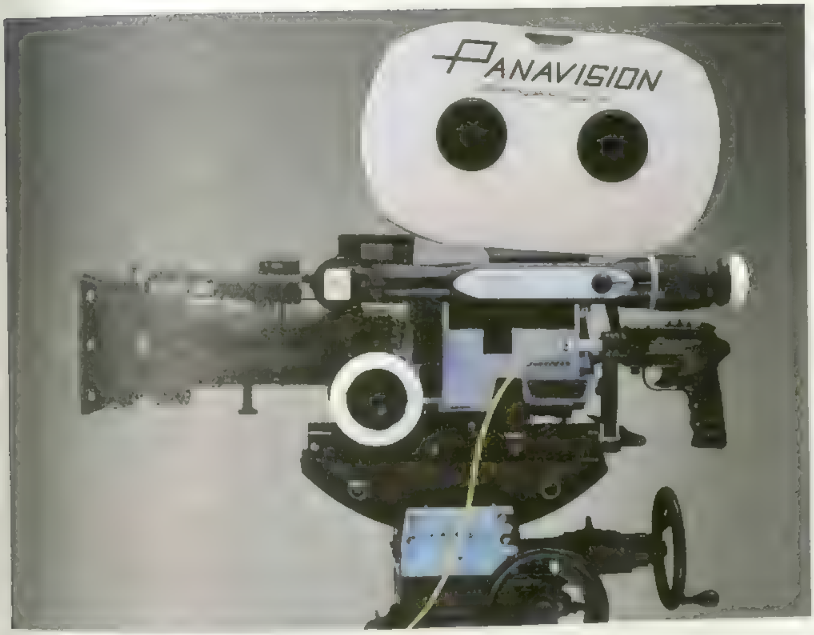
As the composer prepares and records the music, the sound editor adds sound effects, background noises, and additional dialogue. These sounds contribute to the character and impact of the film and strengthen the desired illusion. After the picture has been *locked* and the sound editing completed, the filmmakers take the *final* or *frozen* cut to its final production phases.

Mixing the sound. The various sounds and music are blended together onto one track during a *mixing session* in a dubbing theatre. Several technicians—usually a dialogue mixer, a sound effects mixer, and a music mixer—sit behind a large console with many volume and sound effects controls. In front of them is a screen on which the film is projected. The director watches the film with them as the mixers follow carefully prepared charts known as *cue sheets.* These sheets indicate when each sound occurs in the film's sound tracks. The mixers work together under the leadership of the dialogue mixer. They adjust the relative volume and sound quality of each sound to emphasize the most important sounds.

The answer print. Once the sound has been mixed, the camera original is then edited, shot for shot, to exactly match the final cut of the work print. Next, the laboratories print a new copy on a single, continuous piece of film. They then copy the mixed sound track along the edge of this new print, creating an *answer print.* This version includes the film's titles and credits, as well as optical effects—such as dissolving from one shot to another—that were decided upon during the editing. The film also contains the final mixed sounds in the sound track. Small adjustments can be made at this point. By reprinting, individual shots can be made darker or lighter or their colour can be adjusted.

When the filmmakers believe their work is complete, they preview the picture for an outside audience. Based on the audience's response, whole scenes may be reedited and reprinted. After the filmmakers are satisfied with the film's appearance, the postproduction stage is complete. The product is now ready for distribution to its audience.

In a mixing session, technicians called *mixers* blend the individual sound tracks for the dialogue, music, and sound effects onto a master tape. The mixers watch the screen action as they operate controls on their *sound console* to switch on and balance the various sounds.



A 35-millimetre film camera is a complex piece of equipment. The film is housed in a lightproof, soundproof *magazine* that is mounted on top of the camera. Unexposed film unwinds from a reel in the magazine's *supply chamber.* As the film moves through the camera, it is exposed by light entering through the lens and winds onto a reel in the *take-up chamber.* Knobs on the side of the camera focus the lens and wheels at the base of the camera adjust its position.

As we watch a film, we are actually watching many thousands of individual still pictures called *frames.* Each new frame shows an image slightly different from the image in the preceding frame. When a single image is flashed upon a screen, the human eye continues to see it for one-tenth of a second after the screen has gone black. Because of this phenomenon, called *persistence of vision,* what we see is a continuous flow of action when in fact we are viewing a series of images flashed in rapid succession.

The camera. In principle, a film camera is like a still camera except that it takes many pictures each second. In addition, the camera mechanism is precision-engineered to run almost noiselessly to avoid interfering with sound recording.

The camera lens focuses an image, consisting of light rays, upon a single frame of unexposed film. The image boundaries are precisely defined by a rectangular opening called the *aperture.* After the frame has been exposed, a revolving shutter closes, temporarily shielding the aperture from further light. A metal tooth called a *claw* automatically engages the *sprocket holes* on the side of the film. The claw quickly moves the exposed frame down, pulling a fresh frame into position. While a *register pin* holds the unexposed frame in exact position, the shutter revolves and a burst of light exposes the new frame.

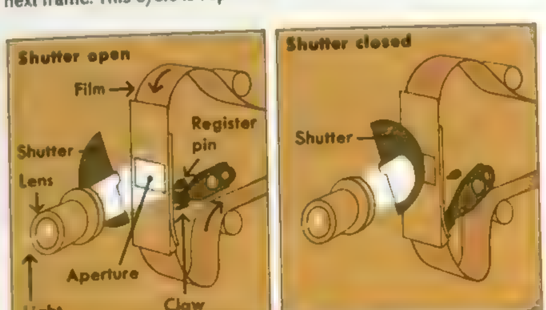
The film's stop-start movement is called *intermittent motion.* This cycle takes place 24 times a second for sound film. For slow-motion filming, the camera mechanism is run faster. For faster motion, the mechanism is run slower than 24 frames a second when filming. The images are then projected at the normal 24 frames a second.

Unexposed film is loaded into the *supply chamber* of a lightproof *magazine,* which can be rapidly mounted and removed from the camera body. After the film has been exposed, it passes into the magazine's *take-up chamber.* It is then unloaded in the dark and sent to a film laboratory for processing.

The film is made of light-sensitive chemicals called *emulsion* coated on a flexible plastic strip called a *base.* Any camera can use either black-and-white or colour film. Film length is expressed in feet or metres, but the standard widths are given in millimetres.

The oldest film in current use is 35 millimetres wide. This size was originally introduced in the late 1800's, and soon became the standard width for making motion pictures. Almost all film shot for cinema exhibition is 35 millimetres wide. Film shot for television and for classroom use is 16 millimetres wide. Home movie film is 8 millimetres wide. The wider the film, the larger the area of the frame and the greater the image's *resolution* (detail).

The shutter controls the length of time that light strikes the film. When the shutter is open, light travels through the lens and an opening called the *aperture* onto the unexposed film. The register pin holds the film motionless until one frame has been exposed. The shutter closes, and the pin then withdraws. A claw is next inserted into the sprocket holes. It pulls the film to the next frame. This cycle is repeated 24 times a second.

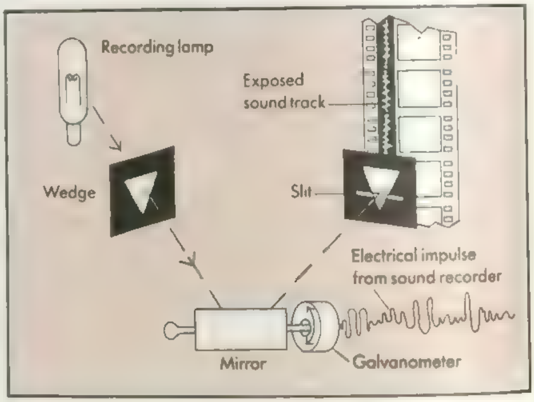


Films projected in cinemas show the largest image and thus use the largest film size. Occasionally, a filmmaker will shoot a film using 70-millimetre film, which is extremely costly but produces exceptionally sharp images on the screen.

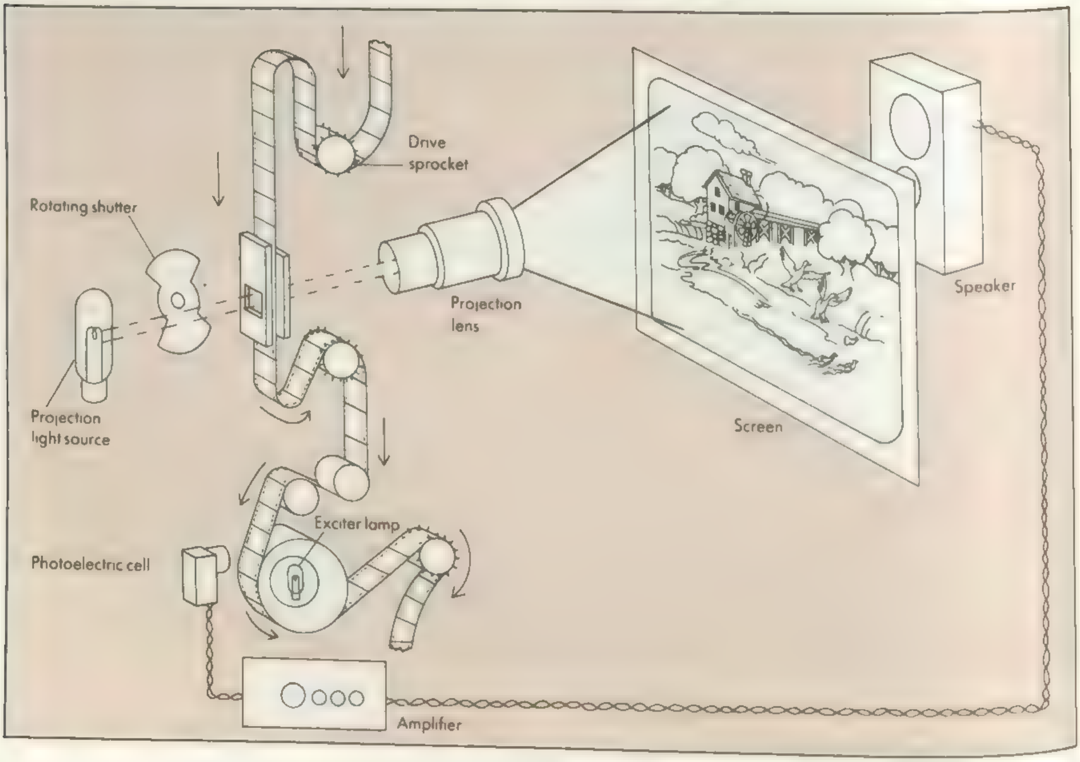
The sound track is a narrow band recorded on the side of the film image. For information on how the sound is mixed and recorded on magnetic tape before being transferred to the film, see the section *How films are made*. The sound track appears on the film as a photographic recording that can be optically played back through a projector.

The sound is transferred from the magnetic tape to the photographic film by means of a *galvanometer*, an instrument that reacts to varying electric currents. At the heart of the galvanometer is a coil of wire that turns when an electric current passes through it. The direction and distance that the coil turns varies according to the direction and strength of the electric current. In this case, the current is produced by the magnetic sound recording. A wedge-shaped beam of light is projected onto a mirror attached to the coil on the galvanometer. As the coil quivers in response to the sound recording, the mirror vibrates accordingly, which in turn makes the reflection of the wedge-shaped beam tremble. This

The sound track is photographed on film by a beam of light, shown by the dashed line. The beam shines from a recording lamp through a lens that shapes it into a wedge and focuses it on a mirror. This mirror vibrates in response to the electrical impulses made by the magnetic tape recording of the sound track. The vibrating mirror reflects the wedge-shaped beam up and down across a slit in another lens. This exposes a pattern of light on the film. The pattern is converted into sound when the film is run through a projector.



The projector mechanism projects the film image onto a screen and also reproduces the sound. The projector has sprockets that pull the film through its mechanism. A rotating shutter prevents light from reaching the film until each frame is stationary. To reproduce the sound, an exciter lamp sends a narrow beam of light through the photographic sound track. The variations of light emerging on the other side shine into a photoelectric cell and are converted into electrical impulses. The impulses are then greatly amplified and fed into the cinema loudspeaker system.



Film for home movies is 8 millimetres wide. TV and classroom films are shot on 16-millimetre film. Most cinema films use 35-millimetre film. Two white bands of sound track run down the left side of the 16-mm and 35-mm films.

trembling beam is reflected through a slit-shaped aperture and onto the film. This action produces a continuously changing area of exposed film called a *variable-area sound recording.*

The projector reproduces the film sound track and throws the visual images onto a screen. Like a camera, the projector has sprockets that pull the film through its mechanism. It also uses the intermittent-motion principle to hold each frame stationary during projection. Some of the earliest cameras could even be adapted to serve as projectors.

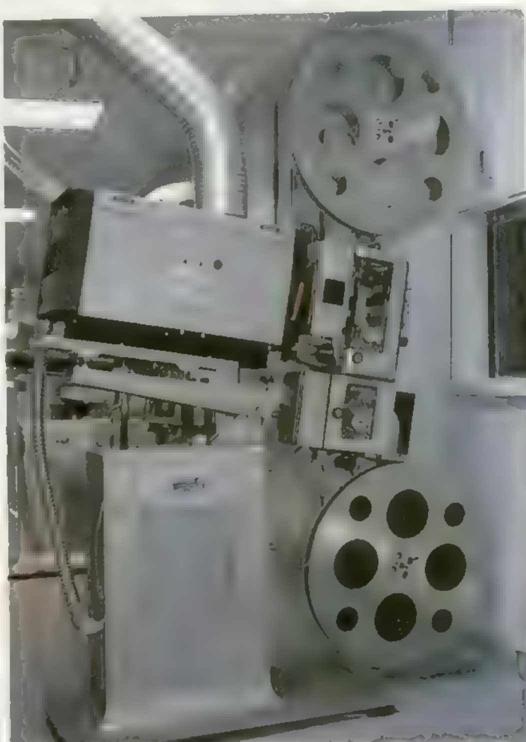
In the modern projector, a rotating shutter prevents light from reaching the film until each frame is stationary. Then the shutter allows the bright light source to shine through the film and project the image through the focusing lens onto the screen. To minimize a flickering image, the shutter produces two short flashes of light for each projected frame instead of one long one. In a single second of film projected at 24 frames a second, there are 48 flashed images. Some projectors use a pulsing light source, which eliminates the need for a shutter.

The projector mechanism must allow for different principles of sound and film reproduction. At the point where the image is being projected onto the screen, the film is moving in the intermittent, start-and-stop fashion just described. However, sound can only be *read* (reproduced) from film in continuous motion. To resolve this problem, the *sound head* – the device that reads the sound track – scans the film after it is past the lens and is again moving in a continuous motion. To permit the image and its matching sound to be reproduced at the same time, the sound must be recorded ahead of its corresponding image on the film. In 35-millimetre film, for example, the sound track is advanced 21 frames ahead of its corresponding image.

To reproduce the sound, an *exciter lamp* sends a narrow beam of light through the photographic sound track. The variations of the light emerging on the other side are converted into electrical impulses by a photoelectric cell. These tiny electrical impulses are then greatly amplified and fed into the cinema loudspeaker system, which converts the impulses back into sound. If a film has a stereo or quadraphonic sound track, multiple sound tracks are recorded on magnetic strips coated on the release print. The strips are read by a projector equipped with magnetic replay heads.

The screen. The typical cinema screen is made of white plastic stretched on a metal or wooden frame. The screen is coated with millions of tiny glass beads. The beads make a highly reflective surface that looks equally bright no matter where the viewer sits in the cinema. Screens differ in size, depending upon the size of the cinema in which they are used. In most countries, the trend has been toward smaller screens to fit the smaller multiple-screen cinemas that have emerged during the late 1900's.

The sound system's loudspeakers are placed behind the screen, which has thousands of small holes that allow the sound to pass through. There are 3 to 6 holes per square centimetre. The holes are too tiny to be seen by the audience, so the sound seems to come from the picture itself.



A 35-millimetre projector is used to show films in cinemas. The projector shown above is equipped with a soundhead that can convert the sound track into four-channel stereo.

The film industry

Films are big business. In the United States, for example, there are 25,000 cinema screens. In the United Kingdom there are about 1,250. In China, there are more than 20,000 million cinema attendances each year, representing an average of 20 visits per person per year. The international cinema is dominated by the United States, but there are flourishing film industries in many other countries, such as Australia, France, India, Japan, and the United Kingdom.

The film industry is divided into three branches—production, distribution, and exhibition. From about 1915 to the late 1940's, large film studios controlled all three branches of the U.S. film industry. The studios not only made the films, they also distributed them to the cinemas, most of which they owned.

In 1948, the Supreme Court of the United States ordered the studios to give up their role as exhibitors. By 1953, most of the U.S. studios had sold their cinemas.

Also during the late 1940's, U.S. studios began to curtail their role in the production of films, partly because of economic competition from television. The studios discovered that, in most cases, they could earn more money by financing and distributing films made by independent producers.

This section deals with the distribution and exhibition branches of the film industry. For information about production see the section *How films are made.* This section also describes attempts by government and private organizations to censor films and the industry's own attempts at self-regulation. The section ends with a discussion of film festivals and awards.

Distribution. Distributors are responsible for advertising the film and delivering it to its audience in cinemas and in homes through television and videocassettes. Major studios serve as the distributor for most films. The remainder are handled by independent distribution companies.

Some producers are able to secure distribution before the film is even made. At this early stage, distributors might be interested in the film because of its star or because the film will be a sequel to a popular film. If the producers have not obtained distribution before filming, they usually wait until the final print of the film is made before presenting it to distributors.

The distributor charges the film's producer a fee of 30 to 50 per cent of all the money the film takes in. A new producer may have to pay a larger fee to attract a distributor than does an established producer with a record of profitable films. Distributors also charge for making the copies of the film sent to the cinemas. In addition, they charge for advertising and publicizing the film. The costs of copying the film, advertising, and publicity come out of the first money the film takes in. The producer receives money only after these costs and the distribution fees have been deducted. The distributor can thus make a profit on a picture, while the film's producer may earn nothing.

After the producer and distributor arrange a distribution deal, the distributor carefully identifies the film's audience. The distributor generally arranges for *sneak previews* to judge the film's effectiveness and to identify its main audience. At a sneak preview, the distributor assembles an audience that may be chosen for such characteristics as age, income level, or occupation. During

A film poster is a crucial part of the advertising campaign designed to attract an audience to a newly released film.

the screening, the distributor's staff usually watches the audience, observing their reactions and level of enjoyment. Afterward, the audience may be asked to fill out information cards on their reaction to the film. They may also discuss their reaction with the distributor's staff. After reviewing the preview responses, the distributor designs the advertising campaign and decides how to release the film to cinemas most effectively. Sometimes the audience responses prompt the distributor to ask the producer to reedit or even reshoot parts of the film.

Films with a broad appeal will receive widespread distribution, perhaps opening in hundreds of cinemas on the same day. Films with more specialized audience appeal generally open in a few carefully selected cinemas in various cities. Widespread distribution is intended to reach quickly the broadest possible audience. The narrower or *platform* approach tries to build and sustain interest in the film over a period of time with good critical reviews and word-of-mouth recommendations from pleased viewers.

Most advertising campaigns are designed to make their heaviest impact for the first two or three weeks of a film's release. If the campaign attracts the right audience and these viewers enjoy the film, they will tell their friends and thus sell the film to a new audience.

A second campaign is sometimes designed to appeal to a different portion of the public. For example, the film may be an action film with a star not usually associated

with action films. The first campaign might reach out to that part of the public interested in action films. The second campaign would be designed to attract that part of the public interested in seeing the star. The advertising campaign and the film's cinema release also prepare the way for the film's release on videocassette, which has become a major market for distributors. Some films are released directly on videocassette, bypassing cinema release entirely.

If the film can earn three times its budget in ticket sales during its first year of domestic release, the producers and their investors will begin to make a profit. The film will then be considered a commercial success. Other sources of revenue include foreign distribution, and sales to television.

Exhibition. Financial arrangements for exhibiting a film can be extremely complicated and may differ from film to film. In the simplest arrangement, the distributor charges an exhibitor a flat fee. More commonly, however, the exhibitor pays the distributor a percentage of the weekly box-office profits (box office receipts minus cinema operating expenses), often with a certain minimum payment guaranteed. For example, a distributor may require a 90 per cent return on profit from an exhibitor during the first week's ticket sales if the film is expected to be a hit. The percentage would then decline in succeeding weeks of the film's run at the cinema. Typically, however, the exhibitor keeps about half of the receipts from ticket sales. The flat fee or percentage the exhibitor pays the distributor is called the film's *rental.*

Cinema owners place bids with distributors for the films they want to exhibit. The limited number of films produced has forced exhibitors to bid higher and higher against one another for the right to rent especially desirable films. To recover the ever-increasing cost of rentals, exhibitors have raised ticket prices. The higher prices have helped make the public more selective in its filmgoing. Cinema audiences have generally declined since the mid-1950's, partly because of higher prices and partly because of competition from television.

Censorship and self-regulation. During the first half of the 1900's, local authorities in some countries had censorship boards that reviewed all films before they could be shown in their areas. Some civic and religious groups also had boards that advised members whether they believed a film to be offensive.

Censorship remained an important factor in the dominant U.S. film industry until the 1950's. Beginning in 1952, the U.S. Supreme Court made a series of decisions that by 1965 had undercut the legality of local censorship boards. Some private censorship groups still exist, but they have less influence than earlier groups had.

The film industry's efforts to regulate itself date back to 1922, when the U.S. movie studios established the Motion Picture Producers and Distributors of America (from 1945, the Motion Picture Association of America). Until 1968 this organization reviewed film scripts before filming began, to delete or amend material that the organization felt might be considered to be offensive by its audiences.

In many countries, the censorship of films is normally governed by similar rules to those restricting the publication of obscene literature. As a rule, cinemas showing films to the public must be licensed. Local government authorities decide on the suitability of films, relying on the judgement of advisory boards. These boards may require cuts in a film or even refuse to allow it to be screened commercially. An example is the British Board of Film Classification, which previews all films intended for public showing in the United Kingdom. It classifies films into one of five categories. They are U, or universal, meaning suitable for all age groups; PG, meaning parental guidance, in which some scenes may be unsuitable for young children; 15 and 18, for people of not less than 15 and 18 years of age, respectively; and Restricted 18, for restricted showing only at cinemas to which no person under 18 is admitted, such as a licensed cinema club.

Festivals and awards. The first major film festival was held in Venice, Italy, in 1932. Today, hundreds of festivals are held annually throughout the world. The largest and probably best-known festival is held in Cannes, France. Other important festivals take place in Venice, Berlin, London, Moscow, New York City, and San Sebastián, Spain.

The best-known film awards are made each spring by the U.S. Academy of Motion Picture Arts and Sciences. These awards, called the *Academy Awards,* or *Oscars,* are presented for outstanding achievements in filmmaking during the preceding year. Other annual film awards include those presented by the Hollywood Foreign Press Association and by the British Academy of Film and Television Arts.

The Oscar is a gold-plated bronze statue presented to winners of the U.S. Academy Awards. The statue received its name in 1931, when an Academy librarian said it resembled her Uncle Oscar.

Academy Award winners*

Best picture

1928-29	*The Broadway Melody*
1929-30	*All Quiet on the Western Front*
1930-31	*Cimarron*
1931-32	*Grand Hotel*
1932-33	*Cavalcade*
1934	*It Happened One Night*
1935	*Mutiny on the Bounty*
1936	*The Great Ziegfeld*
1937	*The Life of Emile Zola*
1938	*You Can't Take It with You*
1939	*Gone with the Wind*
1940	*Rebecca*
1941	*How Green Was My Valley*
1942	*Mrs. Miniver*
1943	*Casablanca*
1944	*Going My Way*
1945	*The Lost Weekend*
1946	*The Best Years of Our Lives*
1947	*Gentleman's Agreement*
1948	*Hamlet*
1949	*All the King's Men*
1950	*All About Eve*
1951	*An American in Paris*
1952	*The Greatest Show on Earth*
1953	*From Here to Eternity*
1954	*On the Waterfront*
1955	*Marty*
1956	*Around the World in 80 Days*
1957	*The Bridge on the River Kwai*
1958	*Gigi*
1959	*Ben-Hur*
1960	*The Apartment*
1961	*West Side Story*
1962	*Lawrence of Arabia*
1963	*Tom Jones*
1964	*My Fair Lady*
1965	*The Sound of Music*
1966	*A Man for All Seasons*
1967	*In the Heat of the Night*
1968	*Oliver!*
1969	*Midnight Cowboy*
1970	*Patton*
1971	*The French Connection*
1972	*The Godfather*
1973	*The Sting*
1974	*The Godfather, Part II*
1975	*One Flew Over the Cuckoo's Nest*
1976	*Rocky*
1977	*Annie Hall*
1978	*The Deer Hunter*
1979	*Kramer vs. Kramer*
1980	*Ordinary People*
1981	*Chariots of Fire*
1982	*Gandhi*
1983	*Terms of Endearment*
1984	*Amadeus*
1985	*Out of Africa*
1986	*Platoon*
1987	*The Last Emperor*
1988	*Rain Man*
1989	*Driving Miss Daisy*
1990	*Dances with Wolves*
1991	*The Silence of the Lambs*
1992	*Unforgiven*
1993	*Schindler's List*
1994	*Forrest Gump*

Best achievement in directing

1927-28	Frank Borzage (*Seventh Heaven*), Lewis Milestone (*Two Arabian Knights*)
1928-29	Frank Lloyd (*The Divine Lady*)
1929-30	Lewis Milestone (*All Quiet on the Western Front*)
1930-31	Norman Taurog (*Skippy*)
1931-32	Frank Borzage (*Bad Girl*)
1932-33	Frank Lloyd (*Cavalcade*)
1934	Frank Capra (*It Happened One Night*)
1935	John Ford (*The Informer*)
1936	Frank Capra (*Mr. Deeds Goes to Town*)
1937	Leo McCarey (*The Awful Truth*)
1938	Frank Capra (*You Can't Take It with You*)
1939	Victor Fleming (*Gone with the Wind*)
1940	John Ford (*The Grapes of Wrath*)
1941	John Ford (*How Green Was My Valley*)
1942	William Wyler (*Mrs. Miniver*)
1943	Michael Curtiz (*Casablanca*)
1944	Leo McCarey (*Going My Way*)
1945	Billy Wilder (*The Lost Weekend*)
1946	William Wyler (*The Best Years of Our Lives*)
1947	Elia Kazan (*Gentleman's Agreement*)
1948	John Huston (*The Treasure of the Sierra Madre*)
1949	Joseph L. Mankiewicz (*A Letter to Three Wives*)
1950	Joseph L. Mankiewicz (*All About Eve*)
1951	George Stevens (*A Place in the Sun*)
1952	John Ford (*The Quiet Man*)
1953	Fred Zinnemann (*From Here to Eternity*)
1954	Elia Kazan (*On the Waterfront*)
1955	Delbert Mann (*Marty*)
1956	George Stevens (*Giant*)
1957	David Lean (*The Bridge on the River Kwai*)
1958	Vincente Minnelli (*Gigi*)
1959	William Wyler (*Ben-Hur*)
1960	Billy Wilder (*The Apartment*)
1961	Robert Wise and Jerome Robbins (*West Side Story*)
1962	David Lean (*Lawrence of Arabia*)
1963	Tony Richardson (*Tom Jones*)
1964	George Cukor (*My Fair Lady*)
1965	Robert Wise (*The Sound of Music*)
1966	Fred Zinnemann (*A Man for All Seasons*)
1967	Mike Nichols (*The Graduate*)
1968	Sir Carol Reed (*Oliver!*)
1969	John Schlesinger (*Midnight Cowboy*)
1970	Franklin J. Schaffner (*Patton*)
1971	William Friedkin (*The French Connection*)
1972	Bob Fosse (*Cabaret*)
1973	George Roy Hill (*The Sting*)
1974	Francis Ford Coppola (*The Godfather, Part II*)
1975	Milos Forman (*One Flew Over the Cuckoo's Nest*)
1976	John Avildsen (*Rocky*)
1977	Woody Allen (*Annie Hall*)
1978	Michael Cimino (*The Deer Hunter*)
1979	Robert Benton (*Kramer vs. Kramer*)
1980	Robert Redford (*Ordinary People*)
1981	Warren Beatty (*Reds*)
1982	Sir Richard Attenborough (*Gandhi*)
1983	James L. Brooks (*Terms of Endearment*)
1984	Milos Forman (*Amadeus*)
1985	Sydney Pollack (*Out of Africa*)
1986	Oliver Stone (*Platoon*)
1987	Bernardo Bertolucci (*The Last Emperor*)
1988	Barry Levinson (*Rain Man*)
1989	Oliver Stone (*Born on the Fourth of July*)
1990	Kevin Costner (*Dances with Wolves*)
1991	Jonathan Demme (*The Silence of the Lambs*)
1992	Clint Eastwood (*Unforgiven*)
1993	Steven Spielberg (*Schindler's List*)
1994	Robert Zemeckis (*Forrest Gump*)

Best performance by an actor

1927-28	Emil Jannings (*The Way of All Flesh, The Last Command*)
1928-29	Warner Baxter (*In Old Arizona*)
1929-30	George Arliss (*Disraeli*)
1930-31	Lionel Barrymore (*A Free Soul*)
1931-32	Fredric March (*Dr. Jekyll and Mr. Hyde*), Wallace Beery (*The Champ*)
1932-33	Charles Laughton (*The Private Life of Henry VIII*)
1934	Clark Gable (*It Happened One Night*)
1935	Victor McLaglen (*The Informer*)
1936	Paul Muni (*The Story of Louis Pasteur*)
1937	Spencer Tracy (*Captains Courageous*)
1938	Spencer Tracy (*Boys Town*)
1939	Robert Donat (*Goodbye, Mr. Chips*)
1940	James Stewart (*The Philadelphia Story*)
1941	Gary Cooper (*Sergeant York*)
1942	James Cagney (*Yankee Doodle Dandy*)
1943	Paul Lukas (*Watch on the Rhine*)
1944	Bing Crosby (*Going My Way*)
1945	Ray Milland (*The Lost Weekend*)
1946	Fredric March (*The Best Years of Our Lives*)
1947	Ronald Colman (*A Double Life*)
1948	Laurence Olivier (*Hamlet*)
1949	Broderick Crawford (*All the King's Men*)
1950	Jose Ferrer (*Cyrano de Bergerac*)
1951	Humphrey Bogart (*The African Queen*)
1952	Gary Cooper (*High Noon*)
1953	William Holden (*Stalag 17*)
1954	Marlon Brando (*On the Waterfront*)
1955	Ernest Borgnine (*Marty*)
1956	Yul Brynner (*The King and I*)
1957	Alec Guinness (*The Bridge on the River Kwai*)
1958	David Niven (*Separate Tables*)
1959	Charlton Heston (*Ben-Hur*)
1960	Burt Lancaster (*Elmer Gantry*)
1961	Maximilian Schell (*Judgment at Nuremberg*)
1962	Gregory Peck (*To Kill a Mockingbird*)
1963	Sidney Poitier (*Lilies of the Field*)
1964	Rex Harrison (*My Fair Lady*)
1965	Lee Marvin (*Cat Ballou*)
1966	Paul Scofield (*A Man for All Seasons*)
1967	Rod Steiger (*In the Heat of the Night*)
1968	Cliff Robertson (*Charly*)
1969	John Wayne (*True Grit*)
1970	George C. Scott (*Patton*)
1971	Gene Hackman (*The French Connection*)
1972	Marlon Brando (*The Godfather*)
1973	Jack Lemmon (*Save the Tiger*)
1974	Art Carney (*Harry and Tonto*)
1975	Jack Nicholson (*One Flew Over the Cuckoo's Nest*)
1976	Peter Finch (*Network*)
1977	Richard Dreyfuss (*The Goodbye Girl*)
1978	Jon Voight (*Coming Home*)
1979	Dustin Hoffman (*Kramer vs. Kramer*)
1980	Robert De Niro (*Raging Bull*)
1981	Henry Fonda (*On Golden Pond*)
1982	Ben Kingsley (*Gandhi*)
1983	Robert Duvall (*Tender Mercies*)
1984	F. Murray Abraham (*Amadeus*)
1985	William Hurt (*Kiss of the Spider Woman*)
1986	Paul Newman (*The Color of Money*)
1987	Michael Douglas (*Wall Street*)
1988	Dustin Hoffman (*Rain Man*)
1989	Daniel Day-Lewis (*My Left Foot*)
1990	Jeremy Irons (*Reversal of Fortune*)
1991	Anthony Hopkins (*The Silence of the Lambs*)
1992	Al Pacino (*Scent of a Woman*)
1993	Tom Hanks (*Philadelphia*)
1994	Tom Hanks (*Forrest Gump*)

Best performance by an actress

1928-29	Mary Pickford (*Coquette*)
1929-30	Norma Shearer (*The Divorcee*)
1930-31	Marie Dressler (*Min and Bill*)
1931-32	Helen Hayes (*The Sin of Madelon Claudet*)
1932-33	Katharine Hepburn (*Morning Glory*)
1934	Claudette Colbert (*It Happened One Night*)
1935	Bette Davis (*Dangerous*)
1936	Luise Rainer (*The Great Ziegfeld*)
1937	Luise Rainer (*The Good Earth*)
1938	Bette Davis (*Jezebel*)
1939	Vivien Leigh (*Gone with the Wind*)
1940	Ginger Rogers (*Kitty Foyle*)
1941	Joan Fontaine (*Suspicion*)
1942	Greer Garson (*Mrs. Miniver*)
1943	Jennifer Jones (*The Song of Bernadette*)
1944	Ingrid Bergman (*Gaslight*)
1945	Joan Crawford (*Mildred Pierce*)
1946	Olivia de Havilland (*To Each His Own*)
1947	Loretta Young (*The Farmer's Daughter*)
1948	Jane Wyman (*Johnny Belinda*)
1949	Olivia de Havilland (*The Heiress*)
1950	Judy Holliday (*Born Yesterday*)
1951	Vivien Leigh (*A Streetcar Named Desire*)
1952	Shirley Booth (*Come Back, Little Sheba*)
1953	Audrey Hepburn (*Roman Holiday*)
1954	Grace Kelly (*The Country Girl*)
1955	Anna Magnani (*The Rose Tattoo*)
1956	Ingrid Bergman (*Anastasia*)
1957	Joanne Woodward (*The Three Faces of Eve*)
1958	Susan Hayward (*I Want to Live!*)
1959	Simone Signoret (*Room at the Top*)
1960	Elizabeth Taylor (*Butterfield 8*)
1961	Sophia Loren (*Two Women*)
1962	Anne Bancroft (*The Miracle Worker*)
1963	Patricia Neal (*Hud*)
1964	Julie Andrews (*Mary Poppins*)
1965	Julie Christie (*Darling*)
1966	Elizabeth Taylor (*Who's Afraid of Virginia Woolf?*)
1967	Katharine Hepburn (*Guess Who's Coming to Dinner*)
1968	Katharine Hepburn (*The Lion in Winter*), Barbra Streisand (*Funny Girl*)
1969	Maggie Smith (*The Prime of Miss Jean Brodie*)
1970	Glenda Jackson (*Women in Love*)
1971	Jane Fonda (*Klute*)
1972	Liza Minnelli (*Cabaret*)
1973	Glenda Jackson (*A Touch of Class*)
1974	Ellen Burstyn (*Alice Doesn't Live Here Anymore*)
1975	Louise Fletcher (*One Flew Over the Cuckoo's Nest*)
1976	Faye Dunaway (*Network*)
1977	Diane Keaton (*Annie Hall*)
1978	Jane Fonda (*Coming Home*)
1979	Sally Field (*Norma Rae*)
1980	Sissy Spacek (*Coal Miner's Daughter*)
1981	Katharine Hepburn (*On Golden Pond*)
1982	Meryl Streep (*Sophie's Choice*)
1983	Shirley MacLaine (*Terms of Endearment*)
1984	Sally Field (*Places in the Heart*)
1985	Geraldine Page (*The Trip to Bountiful*)
1986	Marlee Matlin (*Children of a Lesser God*)
1987	Cher (*Moonstruck*)
1988	Jodie Foster (*The Accused*)
1989	Jessica Tandy (*Driving Miss Daisy*)
1990	Kathy Bates (*Misery*)
1991	Jodie Foster (*The Silence of the Lambs*)
1992	Emma Thompson (*Howard's End*)
1993	Holly Hunter (*The Piano*)
1994	Jessica Lange (*Blue Sky*)

Best performance by an actor in a supporting role

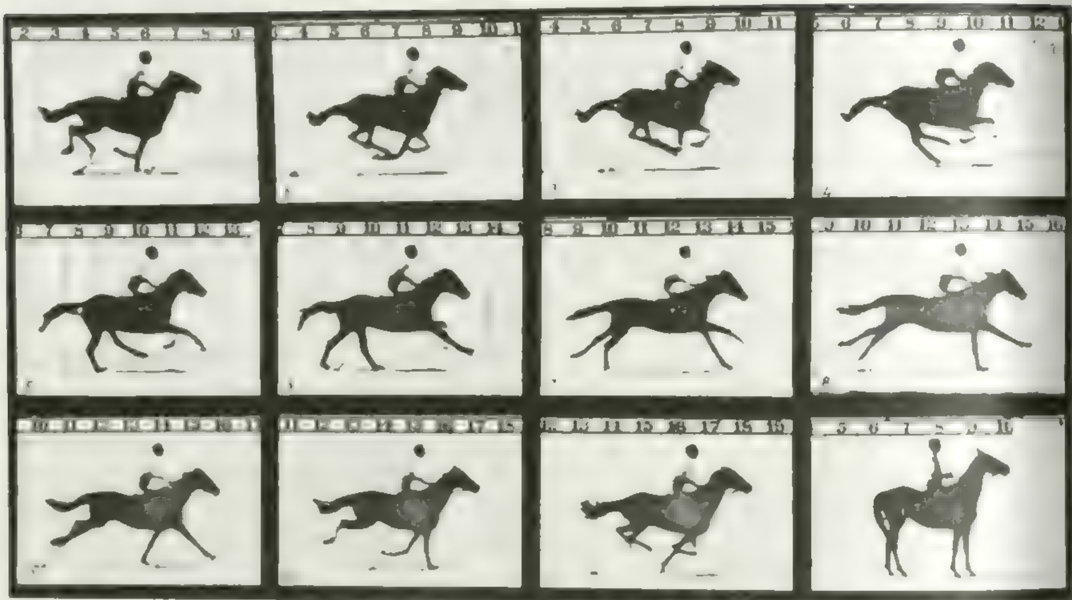
1937	Joseph Schildkraut (*The Life of Émile Zola*)
1938	Walter Brennan (*Kentucky*)
1939	Thomas Mitchell (*Stagecoach*)
1940	Walter Brennan (*The Westerner*)
1941	Donald Crisp (*How Green Was My Valley*)
1942	Van Heflin (*Johnny Eager*)
1943	Charles Coburn (*The More the Merrier*)
1944	Barry Fitzgerald (*Going My Way*)
1945	James Dunn (*A Tree Grows in Brooklyn*)
1946	Harold Russell (*The Best Years of Our Lives*)
1947	Edmund Gwenn (*Miracle on 34th Street*)
1948	Walter Huston (*The Treasure of the Sierra Madre*)
1949	Dean Jagger (*Twelve O'Clock High*)
1950	George Sanders (*All About Eve*)
1951	Karl Malden (*A Streetcar Named Desire*)
1952	Anthony Quinn (*Viva Zapata!*)
1953	Frank Sinatra (*From Here to Eternity*)
1954	Edmond O'Brien (*The Barefoot Contessa*)
1955	Jack Lemmon (*Mister Roberts*)
1956	Anthony Quinn (*Lust for Life*)
1957	Red Buttons (*Sayonara*)
1958	Burl Ives (*The Big Country*)
1959	Hugh Griffith (*Ben-Hur*)
1960	Peter Ustinov (*Spartacus*)
1961	George Chakiris (*West Side Story*)
1962	Ed Begley (*Sweet Bird of Youth*)
1963	Melvyn Douglas (*Hud*)
1964	Peter Ustinov (*Topkapi*)
1965	Martin Balsam (*A Thousand Clowns*)
1966	Walter Matthau (*The Fortune Cookie*)
1967	George Kennedy (*Cool Hand Luke*)
1968	Jack Albertson (*The Subject Was Roses*)
1969	Gig Young (*They Shoot Horses, Don't They?*)
1970	John Mills (*Ryan's Daughter*)
1971	Ben Johnson (*The Last Picture Show*)
1972	Joel Grey (*Cabaret*)
1973	John Houseman (*The Paper Chase*)
1974	Robert De Niro (*The Godfather, Part II*)
1975	George Burns (*The Sunshine Boys*)
1976	Jason Robards (*All the President's Men*)
1977	Jason Robards (*Julia*)
1978	Christopher Walken (*The Deer Hunter*)
1979	Melvyn Douglas (*Being There*)
1980	Timothy Hutton (*Ordinary People*)
1981	Sir John Gielgud (*Arthur*)
1982	Louis Gossett, Jr. (*An Officer and a Gentleman*)
1983	Jack Nicholson (*Terms of Endearment*)
1984	Haing S. Ngor (*The Killing Fields*)
1985	Don Ameche (*Cocoon*)
1986	Michael Caine (*Hannah and Her Sisters*)
1987	Sean Connery (*The Untouchables*)
1988	Kevin Kline (*A Fish Called Wanda*)
1989	Denzel Washington (*Glory*)
1990	Joe Pesci (*GoodFellas*)
1991	Jack Palance (*City Slickers*)
1992	Gene Hackman (*Unforgiven*)
1993	Tommy Lee Jones (*The Fugitive*)
1994	Martin Landau (*Ed Wood*)

Best performance by an actress in a supporting role

1937	Alice Brady (*In Old Chicago*)
1938	Fay Bainter (*Jezebel*)
1939	Hattie McDaniel (*Gone with the Wind*)
1940	Jane Darwell (*The Grapes of Wrath*)
1941	Mary Astor (*The Great Lie*)
1942	Teresa Wright (*Mrs. Miniver*)
1943	Katina Paxinou (*For Whom the Bell Tolls*)
1944	Ethel Barrymore (*None But the Lonely Heart*)
1945	Anne Revere (*National Velvet*)
1946	Anne Baxter (*The Razor's Edge*)
1947	Celeste Holm (*Gentleman's Agreement*)
1948	Claire Trevor (*Key Largo*)
1949	Mercedes McCambridge (*All the King's Men*)
1950	Josephine Hull (*Harvey*)
1951	Kim Hunter (*A Streetcar Named Desire*)
1952	Gloria Grahame (*The Bad and the Beautiful*)
1953	Donna Reed (*From Here to Eternity*)
1954	Eva Marie Saint (*On the Waterfront*)
1955	Jo Van Fleet (*East of Eden*)
1956	Dorothy Malone (*Written on the Wind*)
1957	Miyoshi Umeki (*Sayonara*)
1958	Wendy Hiller (*Separate Tables*)
1959	Shelley Winters (*The Diary of Anne Frank*)
1960	Shirley Jones (*Elmer Gantry*)
1961	Rita Moreno (*West Side Story*)
1962	Patty Duke (*The Miracle Worker*)
1963	Margaret Rutherford (*The V.I.P.'s*)
1964	Lila Kedrova (*Zorba the Greek*)
1965	Shelley Winters (*A Patch of Blue*)
1966	Sandy Dennis (*Who's Afraid of Virginia Woolf?*)
1967	Estelle Parsons (*Bonnie and Clyde*)
1968	Ruth Gordon (*Rosemary's Baby*)
1969	Goldie Hawn (*Cactus Flower*)
1970	Helen Hayes (*Airport*)
1971	Cloris Leachman (*The Last Picture Show*)
1972	Eileen Heckart (*Butterflies Are Free*)
1973	Tatum O'Neal (*Paper Moon*)
1974	Ingrid Bergman (*Murder on the Orient Express*)
1975	Lee Grant (*Shampoo*)
1976	Beatrice Straight (*Network*)
1977	Vanessa Redgrave (*Julia*)
1978	Maggie Smith (*California Suite*)
1979	Meryl Streep (*Kramer vs. Kramer*)
1980	Mary Steenburgen (*Melvin and Howard*)
1981	Maureen Stapleton (*Reds*)
1982	Jessica Lange (*Tootsie*)
1983	Linda Hunt (*The Year of Living Dangerously*)
1984	Dame Peggy Ashcroft (*A Passage to India*)
1985	Anjelica Huston (*Prizzi's Honor*)
1986	Dianne Wiest (*Hannah and Her Sisters*)
1987	Olympia Dukakis (*Moonstruck*)
1988	Geena Davis (*The Accidental Tourist*)
1989	Brenda Fricker (*My Left Foot*)
1990	Whoopi Goldberg (*Ghost*)
1991	Mercedes Ruehl (*The Fisher King*)
1992	Marisa Tomei (*My Cousin Vinny*)
1993	Anna Paquin (*The Piano*)
1994	Dianne Wiest (*Bullets Over Broadway*)

*Academy Awards are presented each spring for outstanding achievements in filmmaking during the preceding year.

History of the cinema



The first successful photographs of motion were pictures of a horse. Eadweard Muybridge, a British photographer in the United States, took them in the 1870's using a row of still cameras.

Since earliest times, people have been interested in portraying things in motion. During the late 1800's, developments in science helped stimulate a series of inventions that led to projected moving pictures on celluloid film. These inventions laid the foundation for a new industry and a new art form.

The first successful photographs of motion were made in 1877 and 1878 by Eadweard Muybridge, a British photographer working in California, U.S.A. Muybridge took a series of photographs of a running horse. For his project, Muybridge set up a row of cameras (first 12, then 24) with strings attached to their shutters. When the horse ran by, it broke each string in succession, tripping the shutters.

The invention of moving pictures. Muybridge's feat influenced inventors in several countries to work toward developing devices to record and re-present moving images. These inventors included Thomas Armat, Thomas Alva Edison, C. Francis Jenkins, and Woodville Latham in the United States; William Friese-Greene and Robert W. Paul in Great Britain; and the brothers Louis Jean and Auguste Lumière and Etienne-Jules Marey in France. Through their efforts, several different types of cine cameras and projectors appeared in the mid-1890's.

Edison's company displayed the first commercial moving-picture machine at the World's Columbian Exposition in 1893. Edison called his machine the *kinetoscope.* It was a cabinet showing unenlarged 35-millimetre black-and-white films running for about 90 seconds. The viewer watched through a peephole as the film moved on spools. Commercial kinetoscopes opened in a number of U.S. cities. However, they were soon replaced by projection machines that threw greatly enlarged pictures on a screen. These new machines allowed many people to view a single film at the same time.

The Lumière brothers held a public screening of projected moving pictures on Dec. 28, 1895, in a café in Paris. Edison, adapting a projector developed by Armat, presented the first public exhibition of projected moving pictures in the United States on April 23, 1896, in a New York City music hall.

Early moving pictures. Film screenings soon became a popular entertainment. In large cities, films were shown in music halls, and in amusement arcades. Travelling projectionists brought the films to smaller cities and country towns. The most popular subjects included re-creations of current news events, and dramatized folk tales. The first buildings designed as cinemas, for the screening of films, opened in the late 1890's.

Films were made without recorded synchronized sound. However, exhibitors sometimes accompanied the images with music or lectures, or even used off-screen live actors to provide dialogue. Later, printed *titles* were inserted within the films. The titles gave dialogue, descriptions of action, or commentary. Titles permitted the international circulation of films, because translated titles could easily replace the originals.

Edison's company dominated the early years of American filmmaking through its control of patents on film-making equipment. Edwin S. Porter, who worked for Edison as a director and cameraman, became a leader in shifting film production from current events toward storytelling. Porter's 1903 film, *The Great Train Robbery,* portrayed a train robbery and the pursuit and capture of the robbers. The 11-minute Western became a sensational hit.

The nickelodeon. Porter's film and the storytelling films that followed opened the way for a major breakthrough in the exhibition of films—the *nickelodeon* movie theatre. From about 1905, thousands of nickelodeons opened, mostly in commercial areas and in the

The first important American film was *The Great Train Robbery,* directed by Edwin S. Porter in 1903. It described a train robbery and the pursuit and capture of the robbers. Porter was the first director to use modern film techniques to tell a story.

The first American cinemas were called *nickelodeons.* Most nickelodeons were shops converted into cinemas by adding a screen and folding chairs. They showed silent films, while a pianist played music that suited the action on the screen.

poorer areas of towns. A shop could be converted into a nickelodeon simply by adding a screen and folding chairs. Nickelodeons were cheaper than the music hall and other forms of live entertainment, and attracted a large audience to films. They laid the foundation for the growing profitability and expansion of the film industry.

The birth of Hollywood. In the early years of filmmaking, in the United States, movies were made in several major U.S. cities. But as the industry developed, filmmakers began working more and more in southern California. They were drawn by a climate suitable for year-round outdoor shooting and by the availability of varied scenery.

By the time World War I broke out in Europe in 1914, a number of companies had established studios in and around the Hollywood district of Los Angeles. After the war ended in 1918, American movies became dominant worldwide and the name "Hollywood" came to stand for the values and style of American films.

D. W. Griffith was the most influential film director during the early years of Hollywood. Griffith pioneered many of the stylistic features and filmmaking techniques

The Birth of a Nation, directed by D. W. Griffith in 1915, was the first American film epic. The film dealt with the American Civil War and the period that followed, and featured spectacular battle scenes. A cameraman can be seen at the lower left.

that became established as the Hollywood standard. His work brought wider appreciation to films as art and helped films attract a more educated and wealthier audience.

Griffith directed hundreds of short films between 1908 and 1913, and a number of feature-length films in later years. Throughout his career, which ended about 1930, he advanced a variety of stylistic improvements. Many filmmakers before and after Griffith regarded films as filmed theatre. They placed the camera a set distance from the performers, photographing the scene from a single viewpoint as a spectator would see it in a theatre. Griffith liberated camera movement. He continually shifted the camera to different distances from the action. He established the close-up shot of a face, a part of a body, or an object as a basic part of film style. Using the close-up, Griffith also led his players toward an acting style of greater realism and psychological depth than was common at that time.

Griffith also revolutionized film editing. Instead of filming an entire scene in one shot, or a few shots, he broke up scenes into many shots, filming from different angles and distances. He extended this idea of film editing to include action at different locations so that the story moved swiftly from place to place. This technique is called *cross-cutting*. Griffith emphasized a quicker tempo of shots, of movement from place to place, and movement within a scene. As a result, his films established a breadth, freedom, and swift pace that characterized the treatment of time and space in many later pictures.

Griffith's most famous, and controversial, work was the epic *The Birth of a Nation* (1915). The film portrayed the American Civil War (1861-1865) and the following period of Reconstruction through the eyes of two families, one Northern and the other Southern. The film was praised as the first great American work of cinema art, but also criticized as racist for its portrayal of blacks and its sympathetic treatment of the Ku Klux Klan.

Louise Fazenda, *left*, and Charlie Murray, *right*, in a scene from a 1917 Keystone comedy

Silent comedies directed by Mack Sennett emphasized improbable and violent situations. Nearly all the important silent comedy stars worked for Sennett at his Keystone Studio.

The Cabinet of Dr. Caligari (1919) was a famous silent German horror film. The distorted sets reflect the twisted mind of the madman who narrates the story.

Films become big business. At about the time *The Birth of a Nation* was released, American film companies were developing a "star system" similar to those of other performing arts, such as theatre and opera. Publicizing performers became the most effective means of promoting films and attracting large audiences. The first highly paid and most popular film stars included dramatic performers Douglas Fairbanks, Sr., and Mary Pickford, cowboy actor William S. Hart, and comedian Charlie Chaplin.

Before World War I, films made in Europe were strong competition for American movies. Mystery serials from France and historical epics from Italy were especially popular. But during the war, European governments diverted raw material from their film industries for military needs. American movie companies seized the opportunity to become the world's strongest film industry. Their successes enabled producers to spend money on lavish costumes and expensive sets. The studios created a sense of glamour around American film stars that appealed to audiences throughout the world.

Within the United States, competition among movie companies led the most powerful studios toward *vertical integration*. This term describes the system in which a studio owned production facilities, distribution channels, and cinemas. Vertical integration gave the studios control of all three major elements of filmmaking: production, distribution, and exhibition.

Several movie companies came to dominate the industry—Columbia, Fox, Metro-Goldwyn-Mayer, Paramount, RKO, United Artists, Universal, and Warner Brothers. They adopted a system in which producers supervised a film's development from script to post-production. Producers, who were usually businessmen rather than film artists, kept a close watch on budgets and schedules. As far as possible, all the people working on the film—the director, writers, designers, crew, and cast—were drawn from the studio payroll.

Vertical integration enabled the companies to use their studio stages efficiently and maintain a high volume of production. But the system placed an even greater emphasis on film stars and familiar, repeatable *genre* films. A genre film is a specific type, such as a Western or a crime melodrama.

Filmmaking in Europe. While American movies remained popular and profitable, more demanding viewers in the 1920's began to look to Europe for new developments in film art. Moviemakers in European countries often competed against American domination of their own cinemas by developing distinctive film styles. This goal was perhaps achieved most successfully in Germany. There, many film directors, writers, and designers were also active in other arts, including painting and live theatre.

In subject matter, German filmmakers stressed fantasy and legend, and also an intense psychological realism not often attempted in American films. The Germans often treated themes in a style drawn from a movement in the arts called *expressionism* (see **Expressionism**). Expressionist films used nonrealistic sets and unusual camera angles to represent a character's inner feelings. The most influential expressionist film was *The Cabinet of Dr. Caligari* (1919), directed by Robert Wiene.

One artistic approach in German cinema stressed lighting and camera movement. German filmmakers created a threatening visual mood to accompany their tales of the supernatural by making scenes darker than normal and by emphasizing contrasting light and shadow. A famous example is the horror film *Nosferatu* (1922), directed by Friedrich Murnau. The same director also made *The Last Laugh* (1924), which told its story entirely through the visual images of the camera, eliminating descriptive and dialogue titles.

Filmmaking made advances in Russia, too, particularly after the Bolshevik (Communist) revolution of 1917. In 1922, the Soviet Union was formed under Russia's leadership, and it existed until 1991. In the Soviet Union, films gained attention as an important medium for education and propaganda. Soviet filmmakers emphasized film editing, refining the *montage,* a technique in which many separate shots are used to create a single point.

Soviet director Sergei Eisenstein developed theories of how the arrangement of shots could create associations in the mind of the audience and stimulate emotions and ideas (see **Eisenstein, Sergei Mikhailovich**). Eisenstein put his ideas into practice in such important films as *The Battleship Potemkin* (1925), which raised the Soviet silent cinema to equality with German films in artistic prestige and influence.

The silent film classics from Germany and the Soviet Union, as well as France, Great Britain, Scandinavia, and elsewhere, were not experienced as silent by audiences. In most large cinemas, the films were accompanied by music, often prepared specifically for the film and played by a large orchestra.

In Australia, a film of the Melbourne Cup horse race was made as early as 1896. Large audiences watched the Tait brothers' *The Story of the Kelly Gang* (1906), which ran for 1 hour 20 minutes, much longer than any other storytelling film made up to that time.

In India, the first domestic film, *Raja Karischandra,* was released in Bombay in 1912. Its writer and director was Dhundiraj Phacke.

The movies talk. During the 1920's, engineers in the United States and Germany were working to develop a technology that could add synchronous recorded sound to films. By the mid-1920's, a few systems were ready for demonstration.

Hollywood musicals of the 1930's became noted for their elaborate staging. Dance director Busby Berkeley staged this spectacular World War I musical number in *Gold Diggers of 1933* (1933).

Scene from *Gold Diggers of 1933* (1933), directed by Mervyn Le Roy

Edward G. Robinson, *right,* in a scene from *Little Caesar* (1930), directed by Mervyn Le Roy

Gangster films were among the most popular of the early sound films. *Little Caesar,* which portrayed the rise and fall of a mobster, became the most imitated gangster picture.

The first sound film to create a sensation was *The Jazz Singer* (1927). Although silent for much of its length, in a few scenes the popular American entertainer Al Jolson sang and spoke in synchronous sound. The film used a system in which the sound from a mechanically recorded disc was mechanically synchronized with the film strip. This system was soon replaced by one that used electronic signals to record the sound directly on the film strip. The sound-on-film system was widely used by 1929.

The coming of sound marked a turning point in the history of the cinema. Some historians claim that sound was actually a setback for the artistic development of films. The emphasis on sound, and the expense of developing it, limited other technological advances that filmmakers had been experimenting with in the 1920's. For instance, a wide-screen process demonstrated by the French director Abel Gance in *Napoléon* (1927) was not generally introduced until the 1950's. What was affected the most, perhaps, was a kind of poetic cinema represented by such silent films as *The Passion of Joan of Arc* (1928), directed by Carl Dreyer of Denmark. Such films survived more as an experimental art form than as part of mainstream commercial cinema.

With the introduction of sound, films went through an awkward period of adjustment. Cameras had to be enclosed in soundproof boxes because the microphones picked up motor noise. More importantly, directors had to learn how best to take advantage of sound. But this adjustment period was brief. By 1931, one of Germany's leading silent film directors, Fritz Lang, had made *M,* a sound film that remains a masterpiece of cinema. In 1928, Walt Disney issued *Steamboat Willie,* the first animated short film to use synchronized sound. For more information about animation in films, see **Animation; Disney, Walt.**

In Hollywood, sound introduced greater changes in personnel than in film style. Sound brought with it a flood of directors, dialogue writers, and, especially, performers from the stage. A number of silent screen stars, notably Greta Garbo and the comedy team of Stan Laurel and Oliver Hardy, successfully made the transition to sound. However, others did not, either because of unsuitable voices or problems with what the studios considered excessive salaries.

Films in the 1930's. Two important new genres in American films came from Broadway in the 1930's, the musical and the gangster picture. Both came to symbolize Hollywood's portrayal of America to an international cinema audience during the Great Depression that followed the stock market crash of 1929. Gangster films like *The Public Enemy* (1931), directed by William Wellman, and *Scarface* (1932), directed by Howard Hawks, dramatized the violence and disorder that accompanied the illegal manufacture and sale of alcoholic beverages during the prohibition era in the United States (1919-1933). Such musicals as *Gold Diggers of 1933* (1933) portrayed a spirit of cooperation and optimism intended to combat the economic depression. The film was one of many Hollywood musicals in the 1930's that featured spectacular dance sequences created by Busby Berkeley.

The worldwide economic decline of the 1930's had a strong impact on the film industry. Interest in sound pictures had nearly doubled annual cinema attendance in the late 1920's. But this fell back in the early 1930's and many film companies lost money.

By the mid-1930's, Hollywood again began to prosper. American film companies developed what many consider one of the greatest periods of popular entertainment filmmaking. During the middle and late 1930's, Hollywood produced major hits in nearly all the familiar genres. In particular, the horror film gained new prominence and the sound comedy emerged as a leading film style. The horror cycle actually began in 1931 with *Dracula,* directed by Tod Browning, and *Frankenstein,* directed by James Whale.

Among the comedy films of the 1930's, perhaps the most popular type was the American *screwball com-*

Screwball comedies were popular during the 1930's. Many portrayed the zany antics of well-to-do characters. Katharine Hepburn and Cary Grant starred in *Bringing Up Baby* (1938).

Robert Donat and Madeleine Carroll in a scene from *The Thirty-Nine Steps* (1935)

The Thirty-Nine Steps was one of director Alfred Hitchcock's earliest successes. He made the thriller in Britain in 1935. Hitchcock later settled in the United States. His best British and American suspense films are noted for their humorous touches and their brilliant camera work.

edy. These films often portrayed the zany antics of well-to-do characters. One such classic comedy was *It Happened One Night* (1934), directed by Frank Capra and starring Clark Gable and Claudette Colbert. Another was *Bringing Up Baby* (1938), directed by Howard Hawks and starring Cary Grant and Katharine Hepburn.

The arrival of sound gave new emphasis to the role of language in cinema. Many countries strengthened their film industries out of national pride in their language and culture. Some countries restricted the importation of American films, in order to encourage their domestic film industry. In most countries, the dialogue of foreign films was translated into the home language. In most English speaking countries, however, such films were almost always played in their original version, with English subtitles projected on the bottom of the film.

The leading film-producing countries of Europe during the silent era, Germany and the Soviet Union, were displaced during the first decade of sound movies by Great Britain and France. Alfred Hitchcock led the emergence of British cinema. He directed a number of internationally successful thrillers, including *The Thirty-Nine Steps* (1935) and *The Lady Vanishes* (1938). In France, Jean Renoir made a series of films during the 1930's that shrewdly observed social attitudes of the time, notably *Grand Illusion* (1937) and *Rules of the Game* (1939).

The rise of dictatorships in Germany and the Soviet Union hampered filmmaking in those countries during the 1930's. After Adolf Hitler seized power in Germany in 1933, a number of German filmmakers went into exile. Many settled in the United States. For example, Fritz Lang began an important career as an American film director with *Fury* (1936) Renoir went to Hollywood after the German occupation of France early in World War II (1939-1945). Hitchcock had already left Great Britain for Hollywood in 1939, though not for political reasons.

While much of Europe's film industry collapsed, and British efforts went into patriotic, semi-documentary films such as Noel Coward's *In Which We Serve* (1942), America's prewar period closed triumphantly with two celebrated films. One was *Gone with the Wind* (1939), an American Civil War drama directed by Victor Fleming and starring Clark Gable and Vivien Leigh. The other was *Citizen Kane* (1941). A young American director and actor named Orson Welles produced, directed, and starred in this story of a powerful American newspaper publisher. In this film, Welles and his cinematographer, Gregg Toland, experimented with startling camera angles and dramatic lighting techniques.

Films and World War II. The role of films in education and propaganda was far more appreciated during World War II than during World War I. After the United States entered the conflict, in 1941, Hollywood directors contributed to the war effort through traditional entertainment movies and through documentary films about the war. Fiction films like *Casablanca* (1943) dramatized the war struggle using the traditional screen narrative

Grand Illusion was a classic antiwar film directed by Jean Renoir of France in 1937 The film is set in a German prisoner of war camp for officers in 1917, during World War I.

Orson Welles produced, directed, and starred in *Citizen Kane* (1941). This biography of a powerful newspaper publisher is famous for its brilliant, experimental photographic effects.

devices of a love story and individual heroism. The film, directed by Michael Curtiz and starring Humphrey Bogart and Ingrid Bergman, became one of the most popular films in screen history.

Postwar realism. The impact of the war led many European directors to make films that focused on society and its problems. This impulse resulted in the emergence of the first important postwar European film movement, *neorealism.*

Neorealist directors were concerned primarily with portraying the daily life of ordinary people. They mainly filmed on location rather than on a studio set, and they used mostly nonprofessional actors and actresses. These qualities gave neorealist films a gritty, almost documentary look.

Italian director Roberto Rossellini made the first internationally significant neorealist films. Rossellini's *Open City* (1945) and *Paisan* (1946) told of the struggle to liberate wartime Italy from its own Fascist government and the later German occupation of the country. Probably the most famous of the neorealist films was *The Bicycle Thieves* (1948), directed by Vittorio de Sica. It follows a workman and his young son as they search for a stolen bicycle. The Italian government regarded the treatment of social problems in these films as harmful to the country's image internationally and passed a law in 1949 hampering their export. The law effectively ended the neorealism movement in Italy.

Thanks to the international impact of neorealism, films and filmmakers previously little known outside their home countries began to gain international recognition. Some of this acclaim resulted from screenings at film festivals. Japanese director Akira Kurosawa brought attention to his country's distinguished film tradition with *Rashomon* (1950). The Latin-American film industry gained recognition with *Los Olvidados* (1950), made in Mexico by Spanish director Luis Buñuel.

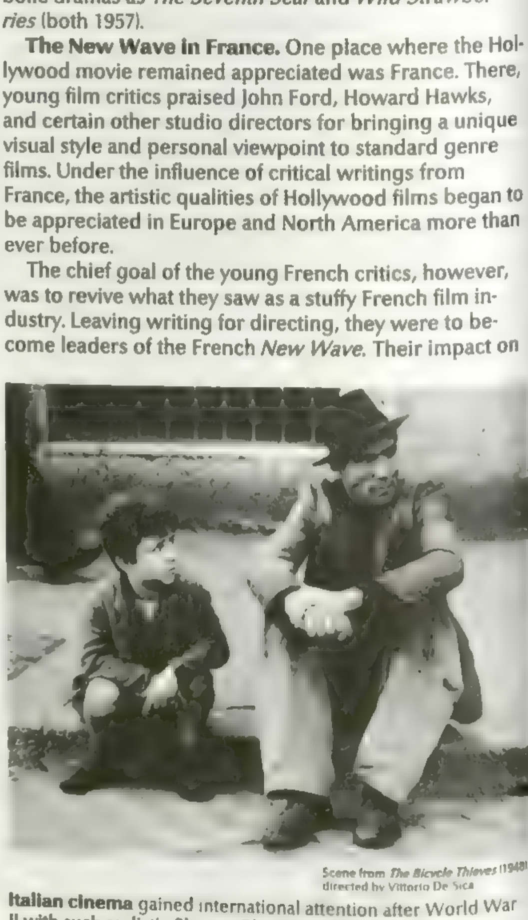
Films in postwar America. In the 1950's, the big U.S. studios declined, and, owing to the increasing popularity of television, attendances at cinemas steadily declined. There was a brief upswing in 1953 and 1954 when the industry introduced wide-screen processes such as CinemaScope and Cinerama. These processes temporarily lured the curious away from their television sets. Still, Hollywood's production volume fell from about 550 films per year before World War II to about 250 a year during the 1950's. Independent production began to take over from the studio system, though studios still functioned as distributors. International coproductions became common, bringing together stars from many countries.

The art film revival. The reduction in Hollywood film production created renewed interest in art films, much as in the 1920's. Serious filmgoers sought out works by such directors as Federico Fellini of Italy and Ingmar Bergman of Sweden.

Fellini became known for such highly personal comedy-dramas as *La Strada* (1954) and *Nights of Cabiria* (1957). Bergman won fame for such brooding and symbolic dramas as *The Seventh Seal* and *Wild Strawberries* (both 1957).

The New Wave in France. One place where the Hollywood movie remained appreciated was France. There, young film critics praised John Ford, Howard Hawks, and certain other studio directors for bringing a unique visual style and personal viewpoint to standard genre films. Under the influence of critical writings from France, the artistic qualities of Hollywood films began to be appreciated in Europe and North America more than ever before.

The chief goal of the young French critics, however, was to revive what they saw as a stuffy French film industry. Leaving writing for directing, they were to become leaders of the French *New Wave.* Their impact on



Scene from *The Bicycle Thieves* (1948), directed by Vittorio De Sica

Italian cinema gained international attention after World War II with such realistic films as *The Bicycle Thieves.* The film concerned a man and his son searching for a stolen bicycle.

Max Von Sydow, *right,* in a scene from *The Seventh Seal* (1957)

The Seventh Seal helped make Swedish director Ingmar Bergman one of the most widely discussed directors in cinema history. Bergman gained fame for a series of films that combined dramatic photography, sensitive acting, and often obscure philosophical and religious themes.

the filmmaking of the 1960's was as profound as that of Italian neorealism several years earlier. Such films as *The 400 Blows* (1959), directed by François Truffaut, and *Breathless* (1960), directed by Jean-Luc Godard, marked the emergence of a new generation of influential film directors.

The years 1959 and 1960 proved to be a key moment in cinema development. Besides the works of Truffaut and Godard, a number of other films showed that a widespread artistic revival was underway. These films included *Hiroshima, Mon Amour* (1959), a French film directed by Alain Resnais; Fellini's *La Dolce Vita* (1960); and Alfred Hitchcock's *Psycho* (1960).

Films in postwar Britain. British cinema became more realistic in the 1950's, which also saw the making of some of the most popular British film comedies. In the late 1940's British cinema had been noted for the work of directors such as David Lean and Sir Carol Reed. Lean directed one of the greatest British postwar films, the romantic drama *Brief Encounter* (1945), as well as acclaimed screen versions of Charles Dickens' novels, such as *Oliver Twist.* Reed became known for several moody dramas, notably *Odd Man Out* (1947) and *The Third Man* (1949). Actor Lawrence Olivier directed and starred in films of Shakespeare's *Henry V, Hamlet,* and *Richard III.*

Jean-Paul Belmondo and Jean Seberg in a scene from *Breathless* (1960)

Breathless was one of the first New Wave hits. It was directed by Jean-Luc Godard and written by François Truffaut, who later became a major New Wave director.

Beginning in 1959, British filmmaking was revolutionized by a series of films that realistically examined working-class life. The film that started the trend was *Room at the Top* (1959), directed by Jack Clayton. Important films that followed included *Saturday Night and Sunday Morning* (1960), directed by Karel Reisz, and *The Loneliness of the Long Distance Runner* (1962), directed by Tony Richardson.

Although the British film industry became increasingly dependent on American finance, it continued to produce some notable films, many of which were international co-productions. They include *Lawrence of Arabia* and *A Passage to India* (1962 and 1984; both directed by David Lean); *Tom Jones* (1963; directed by Tony Richardson); *A Kind of Loving* and *Darling* (1962 and 1965; both directed by John Schlesinger); *This Sporting Life, If,* and *Oh, Lucky Man* (1963, 1968, and 1973, all directed by Lindsay Anderson); *Chariots of Fire* (1981; directed by Hugh Hudson); *Gandhi* (1982; directed by Sir Richard Attenborough); and *The Mission* (1986; directed by Roland Joffe).

Films in postwar Australia. Purely Australian filmmaking collapsed after World War II. The few films made in Australia between 1945 and 1970, such as *The Overlanders* (1947), *On The Beach* (1959), and *Wake in Fright* (1969) were made by overseas companies with foreign directors.

In 1970 the federal government established the Australian Film Commission to encourage and help develop local film production. The South Australian government set up the South Australian Film Corporation, a precedent that was later followed by most other Australian states. Under the South Australian Film Corporation, some of the most outstanding films of the following years were made. They included *Sunday Too Far Away* (1974), *Picnic at Hanging Rock* (1975), *Storm Boy* (1977), *Breaker Morant* (1979), and *Gallipoli* (1981). The Australian directors Peter Weir and Bruce Beresford won worldwide reputations in this period, as did Gillian Armstrong with her film *My Brilliant Career* (1981).

Postwar Asian films. Since the late 1940's, Asian countries have produced more films yearly than have

Peter Bull, *left*, and Peter Sellers, *right*, in a scene from *Dr. Strangelove* (1964)

Dr. Strangelove was a 1964 film that created controversy because it took a comic and satirical view of the possibility of a nuclear war between the United States and the Soviet Union.

European countries and the United States combined. Hong Kong, India, Japan, South Korea, and Taiwan rank among the world's leading producers.

Few Asian films were shown in the West before the late 1940's. During the 1950's and 1960's, Asian films particularly those produced in India and Japan—became popular in the West.

The film industry of India achieved international attention through the work of director Satyajit Ray. He became particularly noted for a series of three motion pictures describing the growth of a boy to manhood in modern India. The series, known as the *Apu Trilogy*, consists of *Pather Panchali* (1955), *The Unvanquished* (1957), and *The World of Apu* (1959). Other Indian filmmakers include Mrinal Sea, Shyam Benegal, Girish Karnad, and Buddhadeb Dasgupta. Indian cinema has won a worldwide reputation, while at the same time producing many popular films for an enthusiastic Indian market. The centre of the Indian film industry is Bombay.

International films in the 1960's and 1970's. The decade of the 1960's saw an appearance of *Cinema Novo* in Brazil, a movement that resembled neorealism. It attempted to combine political subject matter with bold cinema techniques. Such directors as Nagisa Oshima in Japan and Bernardo Bertolucci in Italy became part of the international film scene. Stanley Kubrick, an American director working in Britain, made a number of popular and influential films. The best known was *Dr. Strangelove or: How I Learned to Stop Worrying and Love the Bomb* (1964). The film is a black comedy that satirizes the serious subjects of conflict between the United States and the Soviet Union and the threat of nuclear destruction. Kubrick also directed *2001: A Space Odyssey* (1968), a science-fiction work about future space travel and humanity's self-renewal.

During the 1960's, Eastern European films made their mark on the world scene for the first time. Polish director Roman Polanski's *Knife in the Water* (1962) was the first major international success from Eastern Europe. Czechoslovak cinema soon captured worldwide attention with a series of comic films that criticized social and political conditions. The best known included *Loves of a Blonde* (1965) and *The Firemen's Ball* (1967), directed by Milos Forman; and *Closely Watched Trains* (1966), directed by Jiri Menzel.

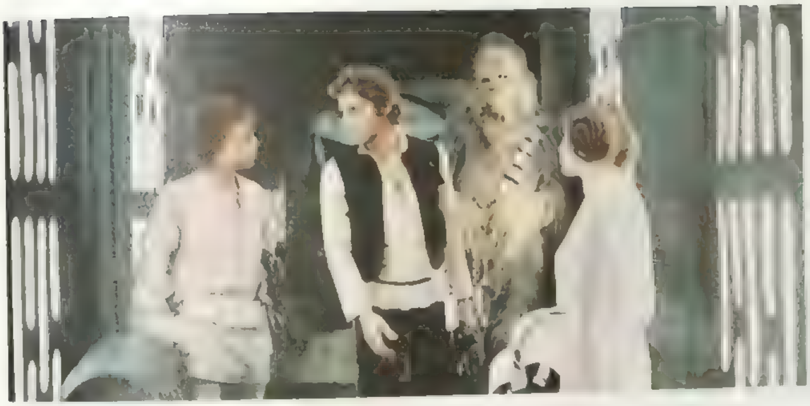
Several Eastern European filmmakers, including Polanski and Forman, emigrated to Hollywood, where they could pursue their craft with greater artistic freedom than they could in their own countries. Forman won the 1975 Academy Award as best director for *One Flew Over the Cuckoo's Nest*.

Changes in Hollywood. Hollywood, and the U.S. film industry, did not share in the world cinema renaissance of the post-1960's era until the coming of new ways of marketing films to the public. For many years, films were released in the U.S.A. slowly, first in a few big cities, then fanning out across the country to smaller cities and towns. In the early 1970's, the movie companies discovered that they might gain greater financial returns by releasing a film in hundreds of cities at the same time, supported by national television advertising.

The new distribution method was used experimentally on director Francis Ford Coppola's *The Godfather* (1972), a much-anticipated film based on a best-selling novel about organized crime. The results were impressive. *The Godfather* earned more than 86 million U.S. dollars at the box-office, making it the most commercially successful film yet produced—dethroning *Gone*

Marlon Brando in a scene from *The Godfather* (1972)

The Godfather was a dramatic account of two generations of a family in the United States who live by organized crime. The film set box office records in the early 1970's.



Star Wars became one of the most profitable films in history. This 1977 science-fiction film describes the adventures of, *left to right,* Luke Skywalker, Han Solo, a hairy creature named Chewbacca, and Princess Leia. They fight the evil forces who terrorize their galaxy with a powerful weapon called the Death Star.

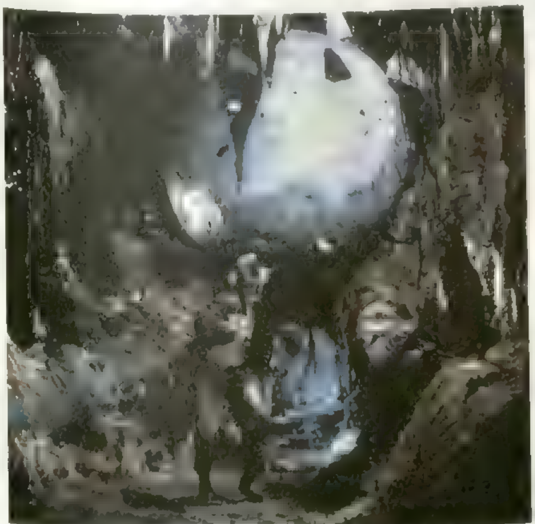
with the Wind, which had reigned as box-office champion for over 30 years. In addition, Coppola was the first of Hollywood's younger directors to make a major impact. His success helped open the door for other young filmmakers.

Steven Spielberg and George Lucas became the most successful of the new generation of U.S. filmmakers who surfaced in the 1970's. They established a remarkable record for producing and directing popular films, such as *Jaws* (1975), directed by Spielberg. Lucas' science-fiction film *Star Wars* (1977) was the first of many highly popular new films to come from Hollywood's own adventure, military, and science-fiction genres instead of a best-selling book.

Spielberg and Lucas succeeded with old-fashioned genre films modernized with spectacular visual effects. Lucas produced two more films in the *Star Wars* series, *The Empire Strikes Back* (1980) and *Return of the Jedi* (1983). Spielberg and Lucas teamed up to make three films that re-created the daredevil adventures of action films of the 1930's and 1940's—*Raiders of the Lost Ark* (1981), *Indiana Jones and the Temple of Doom* (1984), and *Indiana Jones and the Last Crusade* (1989). As co-producer and director, Spielberg made the first film to exceed 200 million U.S. dollars in box-office receipts, *E.T.: The Extra-Terrestrial* (1982). The film was a sentimental fantasy about an alien lost on earth.

Recent developments. Adventure films and fantasies were not the only types of films that revived the enthusiasm of cinema audiences. Hit films of the late 1980's included comedies such as *A Fish Called Wanda,* starring John Cleese; *The Killing Fields,* about the atrocities in Cambodia; *The Accused,* about rape; and *My Left Foot,* the story of a severely handicapped writer.

The hits of the 1980's revived and transformed the film industry, particularly in the United States. Budgets soared as filmmakers combined star attraction and special effects. The gap grew wider between Hollywood's emphasis on blockbuster hits and the more modest resources of filmmakers from other countries. In the



Harrison Ford in a scene from *Raiders of the Lost Ark* (1981)

Raiders of the Lost Ark was a traditional Hollywood adventure film that featured spectacular modern special effects. It was one of several popular films directed by Steven Spielberg.

Australian films gained an international audience in the late 1970's and 1980's with films like *Breaker Morant* (1979), which dealt with an episode in the Australian army during the Boer War.

Holly Hunter *with umbrella* and Anna Paquin in a scene from *The Piano* (1993); Miramax Films

The Piano, a film directed by Jane Campion of New Zealand, brought attention to that nation's filmmaking. The film dealt with the life of a mute woman in New Zealand in the 1800's.

1980's, as in the 1920's and 1950's, artistic developments seemed to come from outside the U.S.

In the 1980's and 1990's, however, the artistic advances centred less on style and more on subject matter. From Asia, Africa, the Middle East, Australia, and elsewhere, came films whose visions of history, culture, and social relations were little known to audiences in other countries. Examples include *The Official Story* (1985) from Argentina, and *Farewell My Concubine* (1993) from China. Some countries, such as Guinea-Bissau and Madagascar, produced their first films in the late 1980's. The freedom movement in the U.S.S.R. and Eastern Europe allowed filmmakers in those countries new opportunities for cinematic expression. Polish director Krzysztof Kieslowski's *Three Colours* trilogy was widely acclaimed. Films throughout the world became more accessible than ever before. This availability resulted from the widespread popularity of videocassette technology, film courses in schools and colleges, film festivals, and screenings in museums.

Australian cinema gained international popularity with such films as *Strictly Ballroom* (1992) and *Muriel's Wedding* (1994). The Indian film industry continued to be hugely successful, concentrating mainly on musicals in Hindi for the Asian market. More serious Indian films to achieve international recognition included Satyajit Ray's last film *Agantuk* (*The Visitor,* 1991), Mira Nair's *Salaam Bombay!* (1988), and Shekhar Kupur's controversial *Bandit Queen* (1993).

During the 1980's and 1990's, films continued to be pulled between the two poles that have influenced their development throughout the century: the small-budget art film and the big-budget, mass-audience film. In the United States, Woody Allen was one of a minority of directors working outside the mainstream. He aimed his comedies at an adult, urban audience, and achieved considerable success with such films as *Annie Hall* (1977), *Hannah and her Sisters* (1986), and *Husbands and Wives* (1992). Spike Lee became a leading black voice in American cinema with *Do the Right Thing* (1989), *Jungle Fever* (1991), and *Malcolm X* (1992).

European cinema was popular with both critics and the public. Its most successful productions were often adaptations of literary works, such as Jean-Paul Rappeneau's version of *Cyrano de Bergerac* (1990) from France, and Kenneth Brannagh's interpretation of William Shakespeare's *Much Ado About Nothing* (1993) from the United Kingdom.

Related articles in *World Book* include:

Actors and actresses

Allen, Woody
Anderson, Dame Judith
Astaire, Fred
Autry, Gene
Barrault, Jean-Louis
Barrymore (family)
Bergman, Ingrid
Bogart, Humphrey
Brando, Marlon
Burton, Richard
Cagney, James
Chaplin, Charlie
Chevalier, Maurice
Cooper, Gary
Crosby, Bing
Davis, Bette
Day-Lewis, Daniel
Dean, James
De Niro, Robert
Dietrich, Marlene
Eastwood, Clint
Fairbanks, Douglas, Sr.
Fairbanks, Douglas, Jr.
Fields, W. C.
Finch, Peter
Finney, Albert
Flynn, Errol
Fonda, Henry
Fonda, Jane
Gable, Clark
Garbo, Greta
Garland, Judy
Gibson, Mel
Gish, Dorothy
Gish, Lillian
Grant, Cary
Guinness, Sir Alec
Hepburn, Katharine
Hoffman, Dustin
Hogan, Paul
Hope, Bob
Hopkins, Sir Anthony
Ives, Burl
Jackson, Glenda
Jolson, Al
Karloff, Boris
Kaye, Danny
Keaton, Buster
Kelly, Gene
Kelly, Grace
Laughton, Charles
Laurel and Hardy
Lloyd, Harold
Marx brothers
Mix, Tom
Monroe, Marilyn
Newman, Paul
Nicholson, Jack
Olivier, Laurence
Pickford, Mary
Poitier, Sidney
Reagan, Ronald
Redford, Robert
Redgrave, Sir Michael
Rogers, Will
Sinatra, Frank
Stewart, James
Streep, Meryl
Streisand, Barbra
Temple, Shirley
Tracy, Spencer
Ustinov, Sir Peter
Valentino, Rudolph
Wayne, John
Welles, Orson
West, Mae

Directors and producers

Allen, Woody
Antonioni, Michelangelo
Balcon, Sir Michael
Bergman, Ingmar
Buñuel, Luis
Capra, Frank
Chauvel, Charles
Clair, René
Coppola, Francis F.
Cukor, George
De Mille, Cecil B.
De Sica, Vittorio
Disney, Walt
Eisenstein, Sergei
Fellini, Federico
Flaherty, Robert J.
Ford, John
Godard, Jean-Luc
Goldwyn, Samuel
Grierson, John
Griffith, D. W.
Hawks, Howard
Hitchcock, Sir Alfred
Huston, John
Kazan, Elia
Korda, Sir Alexander
Kubrick, Stanley
Kurosawa, Akira
Lang, Fritz
Lean, Sir David
Lubitsch, Ernst
Lucas, George
Nichols, Mike
Redford, Robert
Reed, Sir Carol
Renoir, Jean
Sennett, Mack
Spielberg, Steven
Sturges, Preston
Truffaut, François
Von Sternberg, Josef
Welles, Orson
Wilder, Billy
Wyler, William
Zinnemann, Fred

Other related articles

Academy of Motion Picture Arts and Sciences
Animation
Camera
Cartoon
Copyright
Drama
Edison, Thomas A.
Jenkins, Charles F.
Lumière brothers
Photography (Making home movies)
Rank, Lord
Sound
Technicolor
Television
Theatre

Outline

I. How films are made
A. Development
B. Preproduction
C. Production
D. Postproduction

II. How films work
A. The camera
B. The film
C. The sound track
D. The projector
E. The screen

III. The film industry
A. Distribution
B. Exhibition
C. Censorship and self-regulation
D. Festivals and awards

IV. History of the cinema

Questions

What was a *screwball comedy*?
Where and when was the first film festival held?
What is a *take*?
What were the characteristics of *neorealism*?
Who is responsible for the visual look of a film?
How did the coming of sound affect the film industry?
What are *rushes*?
How does filming on a sound stage differ from filming on location?
What is an *option* on a screenplay?

Filmstrip is a related series of still pictures on 35 mm film. A projector projects one after another of these pictures onto a screen. Teachers use filmstrips for instruction. They are easier to use, can be stored in less space, and cost less than slides.

Filmstrips are in black and white or colour. A record player or tape recorder attached to the projector may provide sound for the filmstrips. The recording explains the filmstrip and sometimes has music and sound effects. Some recordings can change pictures automatically by transmitting a silent signal to a special type of projector. Other types give a beep when the operator should change pictures. But teachers often prefer to explain the picture themselves or to have a student do it. In this way, the picture can be changed whenever desired. Students can ask questions immediately instead of waiting until the end of the filmstrip.

Filter is a device that removes unwanted quantities from the flow of liquids or gases, or from the transmission of electric currents, beams of light, or sound waves. Filters that remove solid particles or other impurities from liquids or gases are made from paper, cloth, charcoal, porcelain, fibreglass, or some other porous material. Glass or gelatin filters are used on cameras to filter out certain light rays (see **Photography** (Filters)).

Petrol engines use various types of filters to remove impurities from the air, lubricating oils, or fuel. Dry-paper filters on carburettors remove impurities from the air before it enters the engine. Most oil filters also are made of fibrous paper. Many fuel filters have a stack of ceramic or metal discs separated by narrow spaces, but a few consist of wire screen. Some high-temperature engines also use magnetic filters. The filters attract metallic particles smaller than 1 micron (0.001 millimetre).

Cigarette filters, usually made of cellulose acetate, remove some of the tar and nicotine particles from cigarette smoke. Air conditioners use filters made of fibreglass or metal, coated with an adhesive, to remove dust and pollen from the air. Almost all large cities have filtration plants to filter water.

See also **Air conditioning** (Cleaning the air); **Aquarium** (picture).

Filtration. See **Water** (Purifying and treating water).

Finance. See **Economics; Bank; Budget; Money.**

Finance bill. See **Bill of exchange.**

Finance company is a firm that loans money to people who promise to repay the loan with interest over a specified period of time. Borrowers may be required to offer some guarantee that they will repay the loan, such as a lien on their salary or personal possessions (see **Lien**). Some finance companies also offer credit card services that let the holder buy merchandise. They also make loans to traders and manufacturers. A trader may offer the finance company a purchaser's contract to buy goods on instalment payments as security for a cash loan (see **Hire purchase**). Some finance companies buy these contracts. Business people who need a loan can offer property, merchandise, or unpaid bills owing to them as security.

Finch is a general term applied to any small seed-eating songbird. Finches include buntings, goldfinches, and grosbeaks. True finches are found on all continents except Antarctica and Australia. The commonest finch in Europe is the chaffinch.

The beaks of finches differ in size and shape. The *hawfinch* has a massive beak, which can even crack open cherry stones. The crossed beak of the *crossbill* helps it extract seeds from pine and spruce cones.

Finches build closely woven, cup-shaped nests in the branches of trees and shrubs. They have pleasant, high-pitched calls.

Many species in the bunting family are called finches, including the Darwin's finches of the Galapagos Islands. The zebra finch is a common cage bird that belongs to the waxbill family. Snow finches are related to sparrows and live at high altitudes in snowy regions.

Scientific classification. True finches belong to the finch family, Fringillidae. The chaffinch is *Fringilla coelebs,* the hawfinch is *Coccothraustes coccothraustes,* and the crossbill *Loxia curvirostra.* Some members of the family Estrildidae (waxbills), Ploceidae (weavers and sparrows) and Emberizidae (buntings) are also called finches. The zebra finch is *Poephila guttata.* Snow finches belong to the genus *Montifringilla.*

Related articles in *World Book* include:

Bird	Cardinal	Goldfinch	Junco
Bullfinch	Chaffinch	Grosbeak	Linnet
Bunting	Crossbill	Hawfinch	Towhee

Finch, Peter (1916-1977), an Australian actor, won an Academy Award after his death in 1977 for the role he had played in *Network.* Peter Ingle-Finch was born in London, but emigrated to Australia at an early age. Beginning his stage career in 1936, he made his first film appearance in *Dad and Dave Come to Town* (1937). In 1949, his brilliance was recognized by Laurence Olivier, who encouraged him to join the Old Vic theatre company in London. Further film roles and international fame followed, with such films as *The Battle of the River Plate* (1956), the *Trials of Oscar Wilde* (1960), and *Sunday Bloody Sunday* (1971), establishing Finch as a star.


Peter Finch

Fine is a payment of money ordered by a court from a person who has been found guilty of violating a law. The word comes from the Latin *finem facere,* which means *to put an end to.* The term originated in England in 1275, when the courts began to permit convicts to be released from prison when they paid a required amount of money. A fine is often the punishment for a minor crime. But a fine and a prison sentence can be the penalty for a major crime. People who cannot pay a fine assessed against them are usually ordered to serve a prison sentence.

Fine arts are concerned with making beautiful objects, or with producing or performing works that appeal to a person's aesthetic tastes. People expect to enjoy a poem, a painting, or a symphony for its own sake, not merely as a means to something else. People also expect a great work of art to develop their minds by expressing and clarifying the best thoughts of great people.

Grouping the arts. In a broad sense, the fine arts include music, literature, opera, and ballet, as well as painting, sculpture, architecture, and the decorative arts. Here the word *fine* is often taken to mean *beautiful* or *aesthetically pleasing.* But artists do not always try to make things beautiful or pleasing. Sometimes they try instead to shock or arouse the public to indignation or pity. They may do this by showing the tragic, evil, or ugly sides of life.

In a narrower sense, the fine arts include only the arts that appeal to aesthetic taste through the sense of sight. These arts include painting, sculpture, architecture, landscape design, furniture, ceramics, jewellery, and textile design. Many colleges and universities have departments of "fine arts" that cover only these arts. But most authorities now prefer to call these the *visual arts.* They classify music and spoken literature, as in a dramatic performance, as *auditory arts.* Some authorities group music, dance, and the theatre arts together as *performing arts,* because they must be performed, either by living artists or by mechanical means such as films and records. Many art authorities group painting, sculpture, and architecture together as *plastic arts,* because they consist of solid objects. Works of art that do not move, including most paintings, sculptures, and architecture, are called *static.* Those works that do move are called *mobile,* as in mobile sculptures and animated films. Perfume and cooking are sometimes called *lower-sense arts,* but they are rarely classed as fine arts.

Older groupings. Many people believe that there are seven fine arts. This idea developed in the Middle Ages. Scholars at that time grouped together seven kinds of learning, most of which we call sciences today. This group included grammar, dialectic (a kind of logic), rhetoric, arithmetic, geometry, music, and astronomy.

Another ancient idea is that fine arts can be separated from useful arts, because fine arts are only supposed to be beautiful, not to be useful. This idea developed in ancient times, when people believed that gentlemen and ladies should not use their hands for any useful work. But few people in democratic societies today believe that this is true. We regard architecture, furniture design, and ceramics as fine arts, even though their products are useful, when artists use good design and make their objects satisfying to our eyes, ears, and minds. The Greeks and Romans called all useful skills arts, including agriculture, mining, and medicine. But we regard the hundreds of arts as those concerned with beauty and aesthetic appeal, regardless of their practical use.

Related articles in *World Book* include:

Aesthetics	Drama	Music
Architecture	Drawing	Painting
Art and the arts	Furniture	Poetry
Ballet	Literature	Sculpture
Dancing	Muses	

Fine Gael is one of the chief political parties in the Republic of Ireland. The Fine Gael Party originated from the Cumann na nGaedheal Party, founded in 1923 by supporters of the Treaty of 1921 and the Irish Free State. The Cumann na nGaedheal Party held office from 1923 to 1932. In the 1930's, Cumann na nGaedheal was renamed Fine Gael, which means literally "the tribe of the Irishman." It remained in opposition until 1948. In that year, and in 1954, 1973, 1981, and 1982, it formed coalition governments with other parties. In the latter two coalitions, Fine Gael was led by Garret FitzGerald, in coalition with the Labour Party. In 1987, Fine Gael lost a general election. Soon afterward, FitzGerald resigned as party leader. Alan Dukes was his successor. In 1990, Dukes was replaced by John Bruton as Fine Gael's leader. Bruton became taoiseach in 1994.

See also **Dukes, Alan; FitzGerald, Garret; Ireland, History of; Oireachtas; Taoiseach.**

Finger. See **Hand.**

Finger alphabet. See **Sign language** (picture).

Finger counting. See **Chisanbop.**

Finger painting is a method of painting pictures using the fingers, hands, and arms to apply the paint. A finger painter works with a thick, pasty paint and, in most cases, a wet piece of paper. The painter spreads, rolls, or pats the paint on the paper. The surfaces of the fingers, hands, and arms produce different designs.

Finger painting is enjoyed by both children and adults. The activity appeals especially to youngsters because it is easy and fun. Finger painting provides many adults with a relaxing hobby. It is used as a form of therapy for mentally ill people because it helps them express their feelings. It is also a practical activity for partially sighted people because it stresses movement and does not require attention to visual details.

The standard paper used in finger painting is large and has a glazed side, on which the paint is applied. The paper should be soaked in water and then placed on a smooth, hard surface made of a material that can be washed easily. The painter smooths out all wrinkles and air bubbles from the paper and puts about two tablespoons of paint in the centre of the paper. Beginners should work with one or two colours until they learn the techniques of finger painting. If the paint is too thick or begins to dry, it may be mixed with a few drops of water. Paint can be removed from the paper and hands with a wet sponge or cloth. If a second colour of paint is used, it should be mixed with water to give it the same consistency as the first colour.

Most finger painters work from a standing position, which allows them to move freely. The artist can spread the paint on the paper any way he or she chooses. Some finger painters work in rhythm with music. Artists may create abstract designs, or realistic pictures of birds, flowers, mountains, trees, or other subjects.

After the painting is finished, it should be lifted by the corners and placed on a newspaper to dry. Drying takes about an hour. If the painting wrinkles, press a warm iron against the back to flatten it out. Some artists paint on waterproofed canvas, glass, or other materials that last longer than paper.

No one knows for certain when finger painting began. As early as A.D. 750, Chinese artists created finger paintings.

Finger spelling. See **Deafness** (Special aids and communication techniques); **Sign language**.

Fingernail. See Nail (finger).

Fingerprinting is a process of identification based on the impressions made by the ends of the fingers and thumbs. These impressions consist of patterns formed by the ridges that cover the skin of the fingertips. Fingerprints provide the most reliable method of identification because no person's prints are identical to those of another individual. Even identical twins have different fingerprints. In almost all cases, fingerprints remain the same throughout a person's lifetime. The ridges on the fingertips change only as the result of surgery, disease, or an accident.

Fingerprints are often used in the investigation of crimes. Prints found at the scene of a crime may help investigators identify suspects. Fingerprints that match those in police records serve as strong evidence in court. Fingerprinting may also help prevent crime. For example, some banks, military bases, and government buildings have computers that check the fingerprints of employees before these people are admitted into certain areas. Fingerprints also help identify victims of war; of such disasters as fires, epidemics, and aeroplane crashes; and of other tragedies.

How fingerprints are recorded. Fingerprints are recorded by means of a piece of glass or metal coated with a special ink. The fingertips are pressed into the ink with a rolling motion from one side of the fingernail to the other. The inked fingers are then pressed onto a white card, producing a copy of the prints.

Fingerprints are either visible or *latent* (hidden). Most visible fingerprints are made by fingers soiled with blood, dirt, or other substances. Latent fingerprints are made by the perspiration and oils that accumulate naturally on the fingers.

Visible prints can be photographed immediately, but latent prints must first be *developed* (made visible). Coloured powder is used to develop most latent prints found on nonabsorbent surfaces, such as wood or metal. The powder is *dusted* (brushed) onto the surface, and it sticks to the oils in the prints. The prints are lifted from the surface by pressing a piece of sticky tape against the powder. They are then photographed from the tape. Chemicals are used to develop most latent fingerprints left on absorbent surfaces, such as paper or cloth. The chemicals react with substances in the perspiration left in a fingerprint and form a coloured image of the print. This image is photographed.

Some latent fingerprints can be developed only with a *laser,* a device that produces a powerful beam of light. This light causes the perspiration in a fingerprint to shine with a yellow colour so it can be photographed.

How fingerprints are classified. Fingerprint experts classify fingerprints according to *classification formulas.* Most of these formulas are based on fingerprint patterns and on the number of ridges between certain points within the patterns.

There are four main types of fingerprint patterns. In a *loop pattern,* the most common type, the ridges begin on one side of the finger, curve back sharply, and end on the same side. The ridges in a *whorl pattern* have a circular form. In an *arch pattern,* the ridges extend from

A finger painting, *left,* shows an arrangement of plantlike forms. The picture is an example of the detailed designs that a skilled finger painter can create. The artist used the fingertips, palm, and other parts of the hand and arm to paint this picture.

Fingerprinting is a positive method of identification because no two people have the same fingerprints. Fingerprinting is used by the police in criminal investigations.

one side of the finger to the other, rising in the centre. An *accidental pattern* has no specific form. Many combine loops, whorls, and arches.

History. Before the development of fingerprinting, people identified some criminals and slaves by branding or tattooing them, or by amputating one of their limbs. Other methods included photography and the *Bertillon system,* a technique based on the measurements of the arms, legs, and other parts of the body.

Fingerprinting became a scientific method of identification in the 1880's with the research of Sir Francis Galton, a British anthropologist. Galton calculated mathematically that no two people could have exactly the same fingerprint patterns.

During the 1890's, two police officers, Juan Vucetich of Argentina and Sir Edward R. Henry of Great Britain, developed fingerprint classification systems. Today, computers are used in the classification and comparison of fingerprints.

Some crime laboratories also use evidence called a DNA "fingerprint." DNA, or genetic, fingerprinting is based on the so-called *hypervariable regions* between genes on the chromosomes within cells. These regions consist of sequences of the four bases making up the genetic code, but do not carry any significant genetic information. However, the regions are of different lengths, and the distribution of these lengths is unique for each person.

Using laboratory techniques developed by genetic engineers, it is possible to obtain an image on film of the distribution of hypervariable regions. Such an image, which consists of light and dark bands, can be used to match blood samples found at the scene of a crime to blood samples of possible suspects. Genetic fingerprinting is also used to establish family relationships (see **Heredity** [The chemical basis of heredity]).

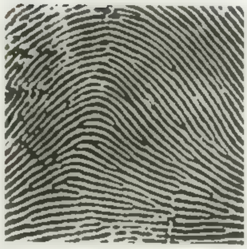
See also **Police laboratory; Footprinting.**

Finite series. See Series (Working with finite series).

How fingerprints are classified

Ridges on the finger form three main groups of patterns—the arch, *below;* the loop, *upper right;* and the whorl, *lower right.* There are eight subclassifications of the main types of patterns.

Loop



Arch

Whorl

A special computer can compare a person's fingerprints with those in a central file. This type of computer is used in some police departments, military bases, and banks to check employees before they are allowed into certain areas.

The DNA fingerprints above were obtained during a police investigation. Sample number 5, obtained from a bloodstain at the scene of the crime, can be seen to match sample number 6, from a suspect.

Finland

Finland is a country in northern Europe famous for its scenic beauty. Thousands of lovely lakes dot Finland's landscape, and thick forests cover almost two-thirds of the land. The country has a long, deeply indented coast, marked by colourful red and grey granite rocks. Thousands of scenic islands lie offshore.

Sweden lies to the west of Finland, northern Norway to the north, and Russia to the east. The Gulf of Finland and the Gulf of Bothnia, two arms of the Baltic Sea, border Finland on the south and southwest. The northernmost part of the country lies inside the *Arctic Circle,* an imaginary line about 2,623 kilometres from the North Pole. In this region of Finland, called the *Land of the Midnight Sun,* the sun shines 24 hours a day for long periods each summer. Helsinki, the country's capital and largest city, is located in the south, on the Gulf of Finland.

Most of Finland's people live in the southern part of the country, where the climate is mildest, though the entire country is snowcovered from December to April. Finns love the outdoors and the arts. They have a high standard of living and receive many welfare benefits from the government. Most of Finland's wealth comes from its huge forests. They form the basis of the country's thriving forest-products industry, which includes woodworking and the manufacture of paper and pulp.

Finland's location between Russia on the east and Sweden on the west has played an important role in the country's history. In the 1000's, Sweden and Russia began to battle for possession of Finland. Sweden gradually gained control in the 1100's and 1200's, but conflict between Sweden and Russia over Finland continued for hundreds of years. Today, Swedish remains equal with Finnish as an official language of Finland. Russia controlled the country from 1809 until 1917, when Finland declared its independence. The country became a republic with a president and parliament. During World War II (1939-1945), Finland fought two wars with the Soviet Union, which was formed under Russia's leadership in 1922, and existed until 1991.

Government

Finland is a democratic republic. Its Constitution, adopted in 1919, guarantees the people such rights as freedom of speech, freedom of worship, and equality before the law. All Finns who are at least 18 years old may vote.

Thick forests and island-dotted lakes cover most of Finland. This small farm lies in the scenic Lake District, a land region that occupies the central part of the country.

Facts in brief about Finland

Capital: Helsinki (in Swedish, Helsingfors).

Official languages: Finnish and Swedish.

Official name: Republic of Finland. Finland's name in Finnish is *Suomi.*

Area: 338,145 km², including 33,522 km² of inland water. *Greatest distances*—east-west, 515 km; north-south, 1,030 km. *Coastline*—2,353 km.

Elevation: *Highest*—Mount Haltia, 1,324 m above sea level. *Lowest*—sea level

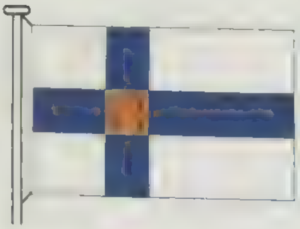
Population: *Estimated 1996 population*—5,059 000; density, 15 people per km²; distribution, 62 per cent urban, 38 per cent rural. *1990 census*—4,998,478. *Estimated 2001 population*—5,123,000.

Chief products: *Agriculture*—milk, pigs, beef cattle, barley, sugar beet, potatoes, oats. *Forestry*—birch, pine, spruce. *Manufacturing*—paper products, machinery, ships, wood products, chemicals. *Mining*—iron ore, copper, zinc.

National anthem: "Maamme" (in Finnish) or "Vårt Land" (in Swedish), meaning "Our Land."

Money: *Currency unit*—markka. One markka = 100 penniä.

Parliament Building in Helsinki is the meeting place of Finland's one-house legislature, the *Eduskunta.* The Eduskunta has 200 members, elected by the people to four-year terms.



Finland's state flag, used by the government, was adopted in 1918. The national flag has no coat of arms.

The Finnish coat of arms was adopted in its present form in 1918. But its basic design dates back to the 1500's.

Finland is a northern European country bordering Sweden, Norway, and Russia. Its coastline stretches along the Baltic Sea.

The president is Finland's head of state and chief executive. The president is elected to a six-year term. The people vote for the president. If no candidate wins a majority of the popular vote, the Electoral College—whose 301 members are chosen by the people—elects the president. A president may be reelected any number of times. The president may issue orders that do not violate existing laws, *veto* (reject) bills passed by the parliament, and dissolve the parliament and call for new elections. The president handles foreign relations and acts as head of the armed forces. But the parliament must approve decisions concerning war and peace.

The prime minister and Cabinet. The president appoints the prime minister, who is head of the government. The prime minister, with the president's approval, forms a Cabinet, which is made up of members of several political parties. The political parties involved must agree on the Cabinet selections. Cabinet members head the government departments. The prime minister presides over the Cabinet and works with it in setting government programmes, which must be acceptable to the parliament.

The parliament of Finland is a one-house legislature called the *Eduskunta* (in Swedish, the *Riksdag*). The people elect its 200 members to four-year terms. The parliament may force the Cabinet to resign by not supporting its programmes. The Eduskunta can also repass a bill by a simple majority vote after the president has vetoed it.

Local government. For purposes of local government administration, Finland is divided into 12 provinces. The president appoints a governor to administer each province. The provinces are subdivided into more than 500 *communes.* The communes range in size from thinly populated rural areas to large cities. A council elected by the people governs each commune. Communes collect their own taxes to support hospitals, schools, police and fire departments, and other local institutions.

Political parties. Election to the Eduskunta is based on a system called *proportional representation.* This system gives a political party a share of seats in the parliament according to its share of the total votes cast in an election. The system encourages small parties to put up candidates and makes it hard for any one party to win a majority. As a result of proportional representation, a number of parties usually have seats in the Eduskunta. See **Proportional representation.**

The Social Democratic Party, supported mostly by working-class and lower-middle-class voters, generally receives the most votes. Other parties include the Centre Party, Christian League, Liberal People's Party, National Coalition (Conservative) Party, People's Democratic League, Rural Party, and Swedish People's Party.

Courts. Finland's highest court of appeal is the Supreme Court. Four regional courts hear appeals from lower courts. Special courts handle such matters as impeachment of government officials and labour disputes.

Armed forces. Finland's armed forces are restricted by treaty to 41,900 people. At present there are about 30,000 men in its army, navy, and air force. Healthy men between 17 and 60 must serve 8 to 11 months in the armed forces.

Cities and towns

Äänekoski	11,481	F	3
Alavus (Alavo)	10,771	F	3
Anjalankoski*	19,917	G	4
Borgå (Porvoo)	19,501	H	3
Ekenäs (Tammisaari)	11 183	H	3
Espoo (Esbo)	153 059	H	3
Forssa	20 054	G	3
Grankulla (Kauniainen)*	7 799	H	3
Haapajärvi	8 449	E	3
Hämeenlinna	42 390	G	3
Hamina	10 313	G	4
Hangö (Hanko)	12 106	H	3
Harjavalta*	8 925	G	2
Heinola	15,990	G	4
Helsinki (Helsingfors)	481,927 •932 376	H	3
Huittinen*	9 504	G	2
Hyvinkää	38 462	G	3
Iisalmi	23,370	E	4
Ikaalinen*	8,211	G	2
Imatra	35,383	G	[illegible]
Jakobstad (Pietarsaari)	20.501	E	3
Jämsä	12 418	G	3
Järvenpää	26 213	G	3
Joensuu	46,329	F	5
Jyväskylä	64 979	F	4
Kajaani	35 938	E	[illegible]
Kankaanpää	13.673	G	2
Karis (Karjaa)	8,356	H	3
Karkkila*	8 331	G	3
Kaskö (Kaskinen)	1,893	F	2
Kemi	26,473	D	3
Kemijärvi	12,873	C	[illegible]
Kerava*	25.834	H	3
Kokemäki (Kumo)*	9,769	G	2
Kokkola (Gamlakarleby)	34 421	E	3
Kotka	59,341	G	4
Kouvola	31,580	G	4
Kristinestad (Kristiinankaupunki)	9,105	F	2
Kuopio	77,330	F	4
Kurikka	11 568	F	2
Kuusankoski	22 250	G	4
Lahti	94 208 •126,358	G	3
Lappeenranta	53 987	G	4
Lapua	14 737	F	3
Lieksa	18,704	E	5
Lohja (Lojo)	14,491	H	3
Loimaa	6,972	G	3
Lovisa (Loviisa)*	8,770	H	4
Mänttä*	8,153	F	3
Mariehamn (Maarianhamina)	9,783	H	2
Mikkeli	29,311	G	4
Naantali	9,984	G	2
Nokia	24,112	G	3
Nurmes	11,488	E	5
Nykarleby (Uusikaarlepyy)	7,795	E	2
Oulainen	8 235	E	3
Oulu	96,274 •129,629	D	3
Outokumpu	9,897	F	4
Pargas (Parainen)	11,541	H	2
Parkano	8 771	F	3
Pieksämäki	14,346	F	4
Pori	78 871	G	2
Raahe	18,905	E	3
Raisio	19 375	G	2
Rauma	30,767	G	2
Riihimäki	24,294	G	3
Rovaniemi	32,240	C	3
Salo	20 267	H	3
Savonlinna	28,567	F	5
Seinäjoki	25,900	F	3
Sköldvik		H	3
Suolahti*	6,358	F	3
Suonenjoki	9 004	F	4
Tampere	167 951 •249,606	G	3
Toijala*	8 032	G	3
Tornio	22,171	D	3
Turku (Åbo)	161 986 •256 687	G	2
Uusikaupunki	13,986	G	2
Vaasa (Vasa)	54 317	F	2
Valkeakoski	22 572	G	3
Vammala	15,903	G	3
Vantaa (Vanda)	142,573	H	3
Varkaus	24,677	F	4
Virrat (Virdois)*	9,524	F	3
Ylivieska	12,568	E	3

*Does not appear on map; key shows general location.
•Population of metropolitan area, including suburbs.
Source: 1984 official estimates.

The gleaming lights of central Helsinki, heart of Finland's capital and largest city, brighten the 18-hour nights of midwinter. The rest of Finland, like Helsinki, is also dark most of the time in winter. About a fifth of the country's people live in Helsinki and its suburbs.

People

Ancestry and population. More than 90 per cent of Finland's people are Finnish by descent, and most of the rest are Swedish. Most people in both groups are tall, with fair skin, blue or grey eyes, and blond or light brown hair.

About 6,000 Lapps live in northern Finland. The ancestors of these short, stocky people lived in Finland long before the first Finns arrived thousands of years ago (see **Lapland**). Finland also has about 6,000 Gypsies and small groups of Jews and Turks.

Finland has a total population of about 5 million. Most of the people live in the south, and about two-thirds of them live in cities and towns. Helsinki, Finland's capital and largest city, has about 500,000 people. About a fifth of the country's people live in Helsinki and its suburbs. Finland has two other cities—Tampere and Turku—with more than 150,000 people living in each. See **Helsinki; Tampere.**

Languages. Finland has two official languages— Finnish and Swedish. About 95 per cent of the people speak Finnish, and about 5 per cent speak Swedish. Most of the Swedish-speaking people live on the south and west coasts and on the offshore Aland Islands. Finnish and Swedish belong to different language families. The Lapps speak a language related to Finnish.

Way of life. In Finland's cities, most people own or rent apartments. Most people in rural areas live in one-family homes on farms or in villages.

The Finns enjoy fish, especially herring, perch, pike, and salmon. Popular meats include beef, veal, and pork. Smoked reindeer is a special treat. Boiled potatoes covered with butter and dill sprigs are a favourite side dish. Butter and milk are important parts of the Finnish diet.

The most famous feature of Finnish life is a special kind of bath called a *sauna.* Most Finns take a sauna at least once a week for cleansing and relaxation. In a sauna room or bathhouse, stones are heated over a stove or furnace. The temperature in the sauna rises to between 80° and 100° C. Bathers sit or lie on wooden benches until they begin to perspire freely. After a while, they may throw water on the stones to produce vapour and make the sauna feel even hotter. The bathers may beat themselves gently with leafy birch twigs to stimulate circulation. Finally, they take a cold shower or plunge into a lake. After repeating the entire cycle, they lie down until their body temperature returns to normal.

Social welfare. The government of Finland provides the people with many welfare services. Since the 1920's, maternity and child welfare centres have given free health care to pregnant women, mothers, and children. Since 1948, families have received an allowance every time they have had a new baby as well as a yearly allowance for each child under the age of 16.

In 1939, Finland began an old-age and disability insurance programme. This provides monthly pensions for people 65 years and older and for the permanently disabled. In 1963, Finland set up a national health insurance programme covering all Finnish citizens.

A Finnish farmwife uses a wood-burning stove for baking. Such stoves are common in rural Finland, where forests provide plentiful wood. About a third of the people live in rural areas.

Lapp schoolchildren in northernmost Finland place their skis against a rack after skiing to school. The Lapp people lived in Finland long before the Finns arrived thousands of years ago.

The government began to guarantee workers annual holidays in the 1920's. Today, workers who remain in the same job for one year receive a 26-day annual holiday. After 10 years, they receive 36 days.

Recreation. The Finns love outdoor sports. In winter, they enjoy ice hockey, ice skating, ski jumping, cross-country skiing, and downhill skiing. Popular summer sports include *pesäpallo* (a Finnish form of baseball), swimming, boating, and hiking. In summer, thousands of city families flock to their cottages and saunas on the lakes, the seacoast, or the offshore islands. Favourite spectator sports include athletics and ice hockey matches. The Finns also enjoy ballets, concerts, films, plays, and operas.

Education. Almost all adult Finns can read and write. All primary school students and most other students go to state schools. The rest attend private schools, which may charge a small tuition fee. Primary school students receive one free meal a day, books, and medical and dental care.

Finland has a *comprehensive school system.* Under this system, children are required to attend primary schools called *basic schools* for nine years. They begin at the age of 7. They attend the lower level of the schools for six years and the upper level for a further three years.

After completing basic school, students may choose to enter an *upper secondary school* or a *vocational school.* Upper secondary schools, which offer three-year courses, emphasize academic subjects. Vocational schools, most of which offer two-year courses, emphasize education in skilled manual work.

Most vocational school students enter the job market after graduating. Graduates of upper secondary schools may apply to a *vocational institute* or a university. Vocational institutes chiefly prepare students for careers in managerial business jobs. The universities offer a wide variety of higher-education programmes.

Finland has 13 universities and 26 other institutions of higher learning. The University of Helsinki is the country's largest university.

Family camping holidays are popular among the Finns, who love the outdoors. Other summer activities include boating; hiking; and playing *pesäpallo,* a Finnish form of baseball.

Finnish glassware is internationally prized for its high quality and simplicity of design. These women are admiring beautiful glass objects on display in a Helsinki shop.

The new town of Tapiola, within the city of Espoo, has become a world-famous model for city planning. A private organization developed it as an entirely new community in the 1950's.

Religion. The Evangelical Lutheran Church is the state church of Finland, and the national government has supreme authority over it. But the people have complete freedom of worship. More than 95 per cent of all Finns are Evangelical Lutherans. The Eastern Orthodox Church makes up the next largest religious group, with about 1 per cent of the population. Finland also has other, smaller Protestant groups as well as small groups of Jews, Muslims, and Roman Catholics.

The arts. Finland has a rich folk culture, which is reflected in the country's crafts, literature, music, and painting. The person most responsible for preserving Finland's oral folklore was Elias Lönnrot, a country doctor. He collected the centuries-old song-poems and chants of the Finnish peasants and published them in 1835. This huge collection, called the *Kalevala,* became Finland's national epic.

During the mid to late 1800's and 1900's, the *Kalevala* inspired many artists. Akseli Gallen-Kallela used its themes in many of his paintings. Composer Jean Sibelius based most of his symphonic poems on the work. American poet Henry Wadsworth Longfellow patterned the rhythm of his poem *The Song of Hiawatha* on the *Kalevala.*

During the early 1800's, Johan Ludvig Runeberg became known as Finland's national poet. His poem "Vårt Land" is now the country's national anthem. Other writers of the 1800's include the novelist Aleksis Kivi and the playwright Minna Canth, an early champion of women's rights. During the 1900's, the novelists Frans Eemil Sillanpää and Mika Waltari gained international fame. Sillanpää won the Nobel Prize for literature in 1939, becoming the first Finn to win the award.

Finnish glassware, ceramics, furniture, and textiles are world famous for the simple beauty of their design. This same simplicity of line and shape can be seen in the works of Finland's best-known architects—Eliel Saarinen and Alvar Aalto. Saarinen's famous designs include the railway station and the National Museum in Helsinki. Aalto gained fame not only as an architect, but also as a town planner and furniture designer.

Land

Finland covers 338,145 square kilometres. This area includes 33,522 square kilometres of inland water. The country is largely a plateau broken by small hills and valleys and low ridges and hollows. The land rises gradually from south-southwest to north-northeast, but the average altitude is only about 120 to 180 metres above sea level. Mount Haltia, the country's highest point, stands 1,324 metres above sea level, in the far northwestern region of Finland. About 60,000 lakes are scattered throughout the country, and forests cover almost two-thirds of the land.

Land regions. Finland has four main land regions: (1) the Coastal Lowlands, (2) the Lake District, (3) the Upland District, and (4) the Coastal Islands.

The Coastal Lowlands lie along the Gulf of Bothnia and Gulf of Finland. Finland's coastline is 2,353 kilometres long. Many small lakes lie in the Coastal Lowlands. The region is less heavily forested and enjoys a milder climate than the Lake and Upland districts. The Coastal Lowlands also have some of the country's most fertile soil. As a result, the region offers the best conditions for farming in Finland. The Coastal Lowlands of the south

Finland terrain map

The Coastal Lowlands along the Gulf of Finland are the home of most of the Finnish people. The town of Borgå, *above,* with its centuries-old wooden buildings, lies in this region.

The Upland District is Finland's northernmost, hilliest, and least densely populated region. Several rivers in the region provide energy for hydroelectric power stations.

have the mildest climate of all and the most productive farms. Most of Finland's people live in this area.

The Lake District occupies central Finland north and east of the Coastal Lowlands. The region has thousands of island-dotted lakes. The lakes cover about half the total area of the district. Narrow channels or short rivers connect many of the lakes. Saimaa, the largest lake in Finland, covers about 1,760 square kilometres in the southeastern part of the region. The Saimaa Lake System, which is about 300 kilometres long, links several lakes in the area. A fleet of steamers travels the system, stopping at towns on the shores of the lakes. Forests of birch, pine, and spruce cover most of the land in the Lake District. Most farmlands in the region lie in the southwestern part of the Lake District.

The Upland District is Finland's northernmost and least densely populated region. It covers about 40 per cent of the country. The Upland District has a harsher climate and less fertile soil than the other regions have. As one travels north through the Upland District, plant life becomes increasingly scarce. Stunted pines and arctic birches grow in parts of the district. However, the northernmost part is a *tundra*—a frozen, treeless plain.

Most of Finland's hills rise in the Upland District. Swamps and marshlands separate the hills. Several rivers in the region provide energy for hydroelectric power stations.

The Coastal Islands consist of thousands of islands in the Gulf of Bothnia and Gulf of Finland. The great majority of these islands are small and uninhabited. The thin, rocky soil on many of the islands cannot support much in the way of plant life, but many kinds of plants thrive on a few of the larger islands. Many of the people who reside on some of the islands fish for a living. However, Finland's islands serve chiefly as summer recreation areas. Many Finns have cottages or saunas on them.

The most important islands are the Åland group, which consists of about 6,500 islands off Finland's southwestern coast. People, almost all of whom speak Swedish, live on about 80 of these islands. The land area of the Åland Islands totals 1,480 square kilometres. The main island, also called Åland, is Finland's largest island. Åland covers 738 square kilometres and is an important tourist and shipping centre. Remains from the Stone, Bronze, and Iron ages abound on Åland. A system of forts, built by the Russians in the 1830s, also survives.

Rivers. Finland's longest river is the Kemijoki. It rises in the Upland District, near the border with Russia, and winds southwestward about 550 kilometres to the Gulf of Bothnia. The Kemijoki and its chief branch, the Ounasjoki, provide important logging routes and rich salmon catches.

The Muonio River begins about 100 kilometres southeast of the point where the Norwegian, Swedish, and Finnish borders meet. The river flows southward for about 180 kilometres, forming part of the border between Sweden and Finland. The Muonio River provides a logging route. The Oulujoki rises in the northern part of the Lake District and empties into the Gulf of Bothnia. The river is only about 130 kilometres long. But it serves as an important logging route. Its 32-metre high Pyhä Falls provides power for a hydroelectric power station.

Climate

Finland has a much milder climate than most other regions of the world that lie as far north. In January, for example, Helsinki's temperatures often average 14° to 18° C higher than the temperatures in parts of Canada at the

same latitude. Finland's climate is influenced chiefly by the Gulf Stream, a warm ocean current that flows off Norway's west coast. Finland's many lakes and the gulfs of Bothnia and Finland help give the country a relatively mild climate.

July temperatures in Finland average 13 to 17 °C. The temperature reaches 10 °C or higher on 110 to 122 days a year in the south and on 50 to 85 days a year in the north. February is usually Finland's coldest month, with temperatures averaging from −22 to −3 °C. In northern Finland, winter temperatures sometimes drop as low as −30 °C.

The amount of *precipitation* (rain, melted snow, and other forms of moisture) varies between southern and northern Finland. The south receives about 70 centimetres a year, and the north only about 40 centimetres. August usually has the heaviest amount of rainfall.

Snow covers the ground in southern Finland from December to April, and northern Finland is snowbound from October to April. Most of the country is icebound in winter, but special icebreaking boats keep the major Finnish ports open so passenger traffic and shipping can continue.

Northern Finland lies in the *Land of the Midnight Sun,* and so has continuous daylight during part of the summer (see **Midnight sun**). The number of days of continuous daylight increases as one goes farther north. Near the Arctic Circle, there is continuous daylight for a few days. In northernmost Finland, the sun stays above the horizon for about 2½ months. Southern Finland never has continuous daylight, though it averages 19 hours of daylight a day in midsummer.

In winter, Finland has similar periods of continuous darkness. In the northernmost areas of the country the sun never rises above the horizon for about 2 months. Southern Finland has some daylight each day, though it receives only about 6 hours of daylight a day in midwinter. The winter night sky—especially in the northern areas of Finland—often becomes enriched with brilliant displays of the *aurora borealis,* or northern lights (see **Aurora**).

Economy

Finland's economy is based mostly on private ownership. However, the national government has a monopoly on certain businesses, such as the railway and postal systems. In forestry and some other industries, government-owned businesses compete with private companies.

Service industries account for 68 per cent of Finland's *gross domestic product* (GDP). The GDP is the total value of goods and services produced within a country in a year. Manufacturing accounts for 19 per cent of the GDP, and construction accounts for 8 per cent. Agriculture, forestry, and fishing—taken together—account for 5 per cent of the GDP.

Natural resources. Finland's greatest natural resource is its widespread forests. They cover almost two-thirds of the land—a higher percentage than in any other European country. But Finland's other resources are limited. Its soil is poor, and the crop-growing season short. The country has no deposits of oil, natural gas, or coal. Hydroelectric power plants produce a large proportion of the country's electricity supply. Finland's most important mineral is zinc. The country also has important deposits of cobalt, copper, and iron.

Forestry plays a leading role in Finland's economy. Forestry and forest-products industries provide about 40 per cent of Finland's exports. The government owns about a third of Finland's forests, chiefly in the north. But these northern forests make up only about 15 per cent of the country's annual forest growth because of the short growing season in the north. Most private forests are owned by individual farmers. They work their farmland during the summer and cut trees in their forests throughout the year. A strict conservation policy protects the forests.

Finland produces more than 37 million cubic metres of timber a year. Pine is the most important variety, accounting for almost half the production, followed by spruce and birch.

Service industries are those economic activities that produce services rather than goods. The leading category of service industry in Finland consists of community, government, and personal services. These services include education, health care, public administration, and recreation. The government controls several large companies in Finland. The second most important category of service industry, in terms of the gross domestic product, consists of finance, insurance, property, and business services. Other service industries, in order of importance, are trade, restaurants, and hotels; transportation and communication; and utilities.

Manufacturing. Woodworking, pulp and paper production, and other forest-based industries are Finland's chief manufacturing industries. Finland ranks as the world's top producer of plywood. The country is also a leading producer of paper and paperboard. Other major forest products include wood panelling and *prefabricated houses,* which are erected in factory-made sections.

Finland's metalworking industry has expanded rapidly since the 1940's. The chief metal products include farm machinery and equipment, electric motors and generators, and machinery for use in the paper and timber industries. Finland also produces buses, ships, and other transportation equipment. The shipbuilding industry is especially known for its sturdy, powerful icebreakers and its ferries. Other manufactured products include chemicals, metals, processed foods, telephones, and textiles and clothing.

Agriculture. Most of Finland's farmland lies in the south and west. The farms are small, averaging about 12 hectares. The Finnish government owns less than 2 per cent of the farmland.

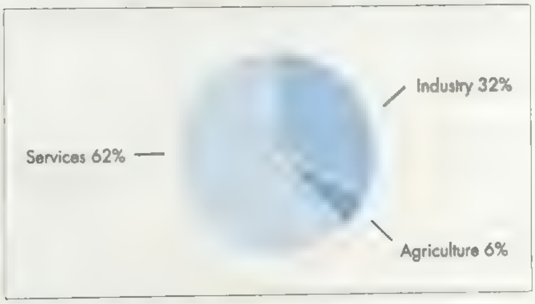
Dairy farming and livestock production account for about 70 per cent of Finland's farm income. Finland's farmers produce all the milk, eggs, and meat needed by the people. They also produce almost all the bread grains needed in Finland. Barley and oats are the main grain crops. Other crops include potatoes, sugar beet, and wheat.

Foreign trade. Finland depends heavily on foreign trade. It imports large quantities of fruit, vegetables, industrial raw materials, manufactured goods not produced in Finland, and petroleum and petroleum products. Wood, wood products, paper, and pulp make up about 40 per cent of the country's exports. Other major

Stacks of timber await loading onto ships at Kotka, a city on Finland's south coast. Timber and other forest products make up about 35 per cent of the country's exports.

Shipbuilding plays an important role in Finland's economy. The industry produces cargo and passenger ships but is best known for its icebreakers. This shipyard is in Helsinki.

Finland's gross domestic product



Finland's gross domestic product (GDP) was 124,543,000,000 U.S. dollars in 1991. The GDP is the total value of goods and services produced within a country in a year. *Services* include community, government, and personal services; finance, insurance, property, and business services; trade, restaurants, and hotels; transportation and communication; and utilities. *Industry* includes construction, manufacturing, and mining. *Agriculture* includes agriculture, forestry, and fishing.

Production and workers by economic activities

Economic activities	Per cent of GDP produced	Employed workers: Number of people	Employed workers: Per cent of total
Community, government, & personal services	26	733,000	33
Finance, insurance, property, & business services	20	191,000	8
Manufacturing	19	471,000	21
Trade, restaurants, & hotels	10	321,000	14
Transportation & communication	9	164,000	7
Construction	8	149,000	7
Agriculture, forestry, & fishing	5	198,000	9
Utilities	3	26,000	1
Mining	*	4,000	*
Total	100	2,257,000	100

*Less than one-half of 1 per cent
Figures are for 1991.
Source: International Labour Organization; Central Statistical Office of Finland.

exports include products of the metalworking industry, such as machinery and ships. Finland also exports millions of farmed furs each year.

Finland's major trading partners include Germany, Sweden, and Russia. On Jan. 1, 1995, Finland became a member of the European Union (EU), an economic organization of European nations. It had been a full member of the European Free Trade Association (EFTA) from 1986 to 1994. The members of both the European Union and EFTA have removed almost all tariffs and other restrictions on imports of manufactured goods from one another. See **European Free Trade Association; European Union.**

Transportation. The government owns most of Finland's railways. The country has a good network of roads and motorways. Finland has an average of about one car for every three people. The Finnish airline, Finnair, is owned mostly by the government. It offers international and domestic flights. As a result of the great distances between many major Finnish communities and the watery nature of the land, Finland has one of Europe's busiest and most extensive domestic air networks. The international airport at Helsinki is the country's busiest airport. It is situated at Helsinki-Vantaa, 19 kilometres from Helsinki. A system of inland waterways connects various lakes and seaports. Sköldvik, near Helsinki, is the country's busiest port.

Communication. Finland publishes about 65 daily newspapers. The largest circulation dailies include *Helsingin Sanomat* of Helsinki, *Aamulehti* of Tampere, and *Turun Sanomat* of Turku. Finland has an average of about one radio for every two people and one television for every three people. The government owns about 90 per cent of the shares in the main radio and television network. Telegraph and telephone lines connect all areas of Finland. The government owns the telegraph

system. The government also owns a large part of the telephone services. Most families have a radio, TV set, and telephone.

History

Early years. The earliest-known inhabitants of Finland were the Lapps. These people lived as *nomadic* (wandering) hunters. Thousands of years ago, the ancestors of present-day Finns began to move into the country from the south shores of the Gulf of Finland. Their original homeland may have been between the Volga River and the Ural Mountains in what is now Russia. The Finns gradually pushed the Lapps farther and farther north. The early Finns were divided into three loosely organized tribes that often fought one another. These people lived a simple life of farming, hunting, and fishing.

In the 1000's, Sweden and Russia began a struggle for control of Finland. Both countries wanted to extend their boundaries. In addition, Sweden wanted to convert the Finns to Roman Catholicism, and Russia wanted to convert them to Eastern Orthodoxy.

Swedish rule. During the 1100's and 1200's, Sweden gradually conquered all Finland and established Catholicism as the official religion. Many Swedes settled in Finland, and Swedish became the official language. But Finns shared equal rights with Swedes. About 1540, the Swedish king Gustavus I made Lutheranism the official religion.

From the 1500's until the end of the 1700's, Sweden and Russia fought several wars over Finland. Russia won the Finnish province of Vyborg after the Great Northern War (1700-1721), which was known in Finland as the *Great Wrath.* For several years during that war and from 1741 to 1743, Russia occupied all Finland. Sweden and Russia fought over Finland again from 1788 to 1790. After the 1788-1790 war, some Finns began to think Sweden could not protect their land. But a plot to create an independent Finland under Russian protection failed to win wide support.

Control by Russia. In 1808, Russia again invaded Finland. It conquered the country in 1809 and made it an independent grand duchy, but with the czar as grand duke. The duchy had local self-rule based on government systems developed during Swedish control. Russia returned Vyborg to the duchy.

During the 1800's, Finns began to develop feelings of nationalism as they took increasing pride in their country and its culture. In 1835, Elias Lönnrot published the *Kalevala,* whose heroic themes strengthened the growing sense of nationalism. Many Finnish leaders began to urge that Finnish be made an official language equal with Swedish. But Finnish did not become a fully equal official language until 1902.

In 1899, Czar Nicholas II began a programme to force the Finns to accept Russian government and culture. He took away most of Finland's powers of self-rule and disbanded the Finnish national army. Russian was made the official language. In 1903, the Russian governor suspended Finland's constitution and became dictator. Finnish resistance reached a peak in 1905 with a six-day nationwide strike. The czar then restored much of Finland's self-government. In 1906, the Finns created their first parliament elected by all adult citizens, women as well as men. During the next several years, Russia again tried to Russianize Finland.

Finland stayed out of World War I (1914-1918). But its merchant ships were blockaded in the Gulf of Bothnia, and the country suffered food shortages and unemployment. In 1917, a revolution in Russia overthrew the czar. Finland then decided to declare its freedom.

The new republic. Finland declared its independence from Russia on Dec. 6, 1917. Russia's new Bolshevik (Communist) government recognized the new country, but some Russian troops remained in Finland. In preparing for independence, the Finns had become divided into two groups—socialists, who formed armed units called the Red Guard, and nonsocialists, who formed armed units called the White Guard. Both groups had demanded Finnish independence, but the socialists also wanted revolutionary social changes.

In January 1918, the White Guard, led by Carl Gustaf Mannerheim, began operations in western Finland to expel Russian troops. Meanwhile, the Red Guard attempted to take over the Finnish government in Helsinki. A bloody civil war broke out between the two groups. The Whites received aid from Germany, and the Reds from Russia. The war ended in a White victory in May 1918.

In 1919, Finland adopted a republican constitution, and Kaarlo Juho Ståhlberg became the first president. But Finland's relations with Sweden and Russia remained unsettled. Finland and Sweden quarrelled over possession of the Aland Islands. In 1921, the League of Nations awarded the islands to Finland. Disputes with Russia centred on Karelia, a large region east of present-day Finland. Finland demanded that the eastern part of Karelia be made part of Finland, like the rest of Karelia, or that it be made independent of Russia. Russia did not accept either of these demands, and relations between the two countries remained tense for years.

World War II (1939-1945). Although Finland never officially allied itself with any country in World War II, the Soviet Union invaded the country twice. The Soviet Union had been formed under Russia's leadership in 1922 and it existed until 1991. The *Winter War* began on Nov. 30, 1939, when Soviet troops marched into Finland.

Important dates in Finland

1100's-1200's Sweden gradually conquered all Finland.

1500's-1700's Sweden and Russia fought several wars for possession of Finland.

1809 Finland became a grand duchy of the Russian Empire.

1917 Finland declared its independence from Russia.

1918 Finnish socialists and nonsocialists fought a civil war.

1919 Finland adopted a republican constitution.

1939-1940 The Soviet Union defeated Finland in the Winter War.

1941-1944 The Soviet Union defeated Finland in the Continuation War.

1946 Finland established a policy of neutrality in international politics.

1955 Finland joined the United Nations (UN) and the Nordic Council.

1981 President Urho Kekkonen resigned from office because of poor health. He had served as president since 1956.

1995 Finland joined the European Union, an economic organization of European nations.

Mannerheim led the strong Finnish resistance, which included troops on skis. But Finland had to agree to a peace treaty in March 1940. Under the peace treaty, Finland was forced to give up the southern part of Karelia, an area where 12 per cent of the Finnish people lived. The area made up a tenth of Finland's territory and included Lake Ladoga and Finland's second largest city, Viipuri (now Vyborg). The Soviet Union also received a naval base on the Hangö peninsula. The base was situated on the southernmost point of the Finnish coast, at the entrance to the Gulf of Finland.

In 1941, Finland allowed Germany to station troops in northern Finland and to move them through the region in order to attack the Soviet Union. The Soviet Union then bombed Finland, beginning the *Continuation War.* Finnish troops recaptured southern Karelia. But in 1944, Soviet troops pushed farther and farther into Finland, and the country had to surrender. On Sept. 19, 1944, Finland and the Soviet Union signed an armistice. As the German troops retreated from northern Finland, they burned towns, villages, and forests behind them.

The destruction by the Germans was only part of Finland's heavy war losses. About 100,000 Finns died, and about 50,000 were permanently disabled. The Soviet Union regained southern Karelia and won other Finnish territories as well. The Soviet Union also leased a military base at Porkkala, near Helsinki, but gave up its base at Hangö. About 420,000 Karelians fled to Finland, where the government gave them new land. Finland also had to pay the Soviet Union large *reparations* (payment for damages). See **Russo-Finnish wars.**

Postwar developments. Mannerheim became Finland's president in 1944, but he retired in 1946 because of poor health. Juho Paasikivi finished Mannerheim's term and was elected to a full term in 1950. Paasikivi set a policy of Finnish neutrality in international politics. Under him, Finland also developed close economic and cultural ties with the Soviet Union and the Scandinavian countries—Denmark, Norway, and Sweden. In 1955, the Soviet Union returned Porkkala to Finland, and the two countries renewed a treaty of friendship and assistance that had been entered into in 1948.

Also in 1955, Finland joined both the United Nations (UN) and the Nordic Council, which includes Denmark, Iceland, Norway, and Sweden. Since Finland joined the Nordic Council, many Finns have moved to Sweden, which has a more developed economy and more extensive social welfare benefits than Finland.

In 1956, Urho Kekkonen was elected president. He continued to emphasize neutrality in international affairs and was reelected in 1962 and 1968. Finland joined EFTA as an associate member in 1961 and became a full member in 1986.

Recent developments. During the late 1970's and early 1980's, Finland completed construction of four nuclear power plants. These plants supply more than a third of the nation's energy needs. Finland hopes to improve the economy in the underdeveloped north and so relieve overcrowding in the booming south.

In January 1973, Finland's parliament passed a bill to extend Kekkonen's term from 1974 to 1978. The parliament hoped the bill would assure the Soviet Union that Kekkonen's neutral policies would not change because of the agreements with the European Community. Kekkonen was reelected in 1978. In September 1981, he took a medical leave from office and Prime Minister Mauno Koivisto became acting president. Kekkonen resigned from office in October 1981 because of poor health. Koivisto was elected president in January 1982. Kekkonen died in 1986. Koivisto was reelected in 1988. In 1994, Martti Ahtisaari, of the Social Democratic Party, was elected to succeed him. He was the first president to be elected by direct popular vote. On Jan. 1, 1995, Finland withdrew from EFTA and joined the European Union.

Related articles in *World Book* include:

Biographies

Aalto, Alvar
Kekkonen, Urho
Mannerheim, Carl G.
Saarinen, Eero
Saarinen, Eliel
Sibelius, Jean

Other related articles

Helsinki
Lapland
Russo-Finnish wars
Sauna
Tampere
Tapiola

Outline

I. Government
- A. The president
- B. The prime minister and cabinet
- C. The parliament
- D. Local government
- E. Political parties
- F. Courts
- G. Armed forces

II. People
- A. Ancestry and population
- B. Languages
- C. Way of life
- D. Social welfare
- E. Recreation
- F. Education
- G. Religion
- H. The arts

III. Land
- A. Land regions
- B. Rivers

IV. Climate

V. Economy
- A. Natural resources
- B. Forestry
- C. Service industries
- D. Manufacturing
- E. Agriculture
- F. Foreign trade
- G. Transportation
- H. Communication

VI. History

Questions

What are Finland's two official languages?
In which region of Finland do most of the people live?
How has Finland's location between Russia and Sweden influenced its history?
What are the chief manufacturing industries in Finland?
What is the *Kalevala*? How has it affected Finnish arts?
Why does Finland have a much milder climate than most other regions of the world that lie as far north?
What area did Finland give the Soviet Union after the Winter War?
What is a *sauna*?
What are some of Finland's social welfare policies?
About how many lakes does Finland have?

Finlay, Carlos Juan (1833-1915), a Cuban doctor, was the first person to report evidence that yellow fever might be transmitted by the bite of the *Stegomyia* mosquito (*Aëdes aegypti*). The American Yellow Fever Commission went to Havana, Cuba, in 1900, and Finlay convinced its members that his theory was correct. Finlay was born in Puerto Principe (now Camagüey), Cuba. He was chief sanitary officer of Cuba from 1902 to 1908. He studied at Jefferson Medical College in Philadelphia, Pennsylvania, U.S.A. See also **Yellow fever.**

Finn MacCool was leader of the Fianna, an Irish band of warriors who appear in the Fenian cycle of ancient Irish tales. His name is also spelled *MacCumhal.* The tales are set in the province of Leinster, in about A.D. 200. Finn is also a familiar figure in Irish folk tales, sometimes portrayed as a giant. Several tales tell how Finn burned his thumb while cooking the salmon of knowledge. He put his thumb in his mouth to ease the pain. From that day, he had only to put his thumb in his mouth when he was perplexed to discover the solution to a problem. See also **Mythology** (The Irish cycles).

Finney, Albert (1936-), a British actor and director of plays and films, achieved his first success in the realistic drama of the 1950's and 1960's. He played the leading roles in the play *Billy Liar* (1960) and the films *Saturday Night and Sunday Morning* (1960), *Tom Jones* (1963), and *Night Must Fall* (1964). In 1961, he played Martin Luther in the play *Luther.* He directed and acted in the film *Charley Bubbles* (1968).

During the 1970's, Albert Finney acted in such classical stage dramas as *The Cherry Orchard* (1978) and *Macbeth* (1978). During the 1980's, he appeared in such films as *Shoot the Moon* (1982), *The Dresser* (1984), and *Under the Volcano* (1984). Finney was born at Salford, in Greater Manchester, England. He studied at the Royal Academy of Dramatic Arts.

Finnian of Clonard, Saint (? -549), helped develop the early Church in Ireland. He founded a monastery at Aghowle in County Wicklow, and, in about 520, he founded Clonard, another monastery. Clonard grew until it had 3,000 pupils. St. Finnian, an excellent teacher, has been called teacher of the saints of Ireland. His book of rules for monks still survives. St. Finnian was born in Leinster, Ireland. He studied in Ireland and, later, in Wales, with St. David. His feast day is December 12.

Finnish spitz is a strong, sturdy dog related to the Siberian husky, the Samoyed, and other Arctic dogs. A Finnish spitz looks somewhat like a fox. The dog has a thick, red-gold coat; erect, pointed ears; and dark brown eyes. Its bushy, curled tail falls over its hindquarters. The male Finnish spitz stands from about 45 to 50 centimetres tall at the shoulder and weighs about 14 kilograms. The female is a slightly smaller animal.

The Finnish spitz is the national dog of Finland.

The Finnish spitz is the national dog of Finland. It is descended from dogs used for hunting by the early Finns. Finns still use the dog to hunt game birds. Outside Finland, however, the Finnish spitz is kept primarily as a pet. The dog is intelligent and good-tempered.

Finns. See **Finland** (People).

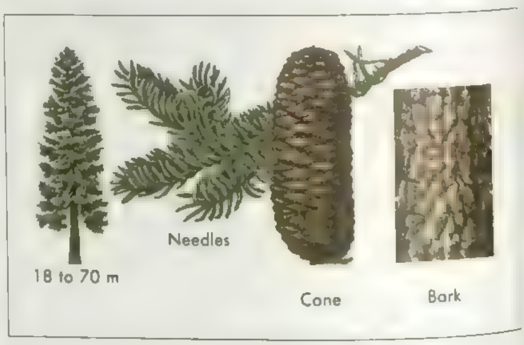
Fiord, also spelled *fjord,* is a long, narrow, winding inlet or arm of the sea. *Fjord* is a Norwegian word, applied to the deep bays and inlets along the ragged and mountainous coastline of Norway. Geologists believe that rivers cut these fiords, and glaciers deepened them millions of years ago. Most fiords also have shallow *sills* (underwater ridges) at their mouths that become more deeply submerged further inland.

The coasts of Alaska and Maine, in the U.S.A.; British Columbia, in Canada; Greenland; and New Zealand contain inlets similar to Norway's fiords. *Sea loch* or *firth* is the name for such an inlet in the United Kingdom.

See also **Firth; Norway** (Coast and islands).

Fir is the common name for about 50 *species* (kinds) of evergreen trees that belong to the pine family. Firs grow in the Northern Hemisphere. Many species live in humid locations by the coast or on mountain slopes.

Fir trees have an overall pyramid shape, and dense foliage. The needle-shaped leaves do not grow in clusters



The California red fir grows in the mountains of western North America from Canada to southern California.

like pine needles, but are distributed evenly all around the branches. They are usually soft, blunt, and fragrant. In many species, the needles are dark green on top and have two light coloured lines on the bottom surface.

Fir trees have distinctive cylinder-shaped cones that grow upright on the branches. When the cones mature, they shed their scales, leaving a bare, spinelike axis. The bark of the young trees contains blisters that are filled with a resin called *balsam.* The resin of the *balsam fir* of Canada and the northern United States is used as a high-quality cement for glass in optical instruments (see **Balsam fir**). The scented needles of this species of fir are used to give a "pine" fragrance to some soaps and other toiletries.

Because of their attractive shape and fragrance, firs are widely used as Christmas trees. Some firs are also valuable timber trees, especially the *silver fir* of Europe and the *California red fir* of the Western United States. The *Douglas fir,* another valuable timber tree, is not a

true fir. It belongs to a separate *genus* (group) of the pine family.

Scientific classification. Firs belong to the pine family, Pinaceae. The balsam fir is *Abies balsamea,* the silver fir is *A. alba,* the California red fir is *A. magnifica.* The Douglas fir is *Pseudotsuga menziesii.*

See also **Balsam; Conifer; Douglas fir; Tree.**

Firdausi, also called Firdusi (940?-1020?), means the *Heavenly One.* It was the name taken by Abul Qasim Mansur, one of the great epic poets of Persia (now Iran). His *Shah-Namah* (Book of Kings) traces the history of Persia from its mythical period, perhaps before 3600 B.C. to the time of the Muslim conquest in A.D. 641. It is a poem of 60,000 lines, and is about seven times as long as the *Iliad.* Iranian folklore now includes parts of the poem.

Fire. The earliest use people made of fire was to keep warm. As civilizations advanced, people learned to use fire in many other ways. People learned to use fire to cook food, to shape weapons and tools, to change clay into pottery, and to furnish light. But early peoples had extremely slow and quite unsatisfactory ways of kindling fires.

Today, we have not only improved the methods of kindling fires, but we also use fire in many more ways. Fire furnishes the energy to drive machines, and keeps industries running. It supplies the power to drive trains, ships, and planes; and it generates electricity. Fire is also sometimes used to remove and destroy waste materials. In addition, fire is used in separating most metals from their ores, as well as in forging and shaping metals into useful things.

Controlled fire is useful. But fire can also be destructive. Uncontrolled fire kills thousands of people and destroys thousands of properties each year. Fires burned down large parts of London in 1666, Chicago in 1871, and Tokyo in 1923. Fires also destroy large areas of trees and brush every year.

What is fire?

Fire is the heat and light that comes from burning substances. In 1777, Antoine Lavoisier, a French chemist, proved that burning is the result of the rapid union of oxygen with other substances (see **Lavoisier, Antoine L.**). As a substance burns, heat and light are produced. Burning is also called *combustion.* Often oxygen unites with other substances at such a slow rate that little heat and no light are given off. When this happens, we call the process *oxidation,* rather than *burning* or *combustion.* Oxidation takes place whenever oxygen unites with other substances, either rapidly or slowly. For example, when oxygen unites with petrol, the action takes place rapidly and heat and light are given off. This process may be described by any of the three words, burning, combustion, or oxidation. When oxygen unites with iron and causes it to rust, burning, or combustion, does not take place, but oxidation does.

Kinds of fire. All substances do not burn in the same manner. Charcoal, for example, gives off heat with a faint glow. But other substances, such as coal, gas, magnesium, oil, and wood, give off heat with a flame. The colour of the flame depends chiefly on the kind of material being burned and on the temperature.

Substances may burn in different ways, but they all require oxygen to burn. Sometimes old rags soaked with oil or paint are thrown aside and forgotten. Oxygen from the air may slowly unite with the oil in the rags. At first, there will not be a fire. But as oxidation gradually takes place, enough heat accumulates to set the rags on fire. This type of burning, called *spontaneous combustion,* causes many fires.

Very rapid burning may cause explosions like those produced by gunpowder and dynamite. Here, oxidation takes place so rapidly that great volumes of gases are produced. These require many hundreds of times the space that was formerly occupied by the gunpowder or

Controlled fire is essential in various industrial processes, especially in the manufacture of steel, shown here. Intense flames melt scrap iron, iron ore, and other raw materials in an open-hearth furnace to produce molten steel.

Uncontrolled fire, like this house fire, can be extremely destructive. Such fire kills thousands of people and destroys thousands of properties every year. Water puts out fire by cooling the burning materials.

dynamite before the oxidation took place. These gases expand so rapidly and violently that they produce an explosion.

How fire is produced. Three conditions must exist before a fire can be made. First, there must be a fuel or a substance that will burn. Second, the fuel must be heated to its *ignition temperature.* This is the lowest temperature at which combustion can begin and continue. Finally, there must be plenty of oxygen, which usually comes from the surrounding air.

Fuels are of three types: solids, liquids, and gases. Coal and wood are examples of solids. Oil and petrol are liquid fuels. Natural gas and hydrogen are gaseous fuels.

The burning of a solid fuel often depends on the form of the fuel. For example, you may not be able to light a large log with a match, but a small twig from the same tree may catch fire easily with the same match. This is because heat flows to the inside of the log, and the log cannot maintain a high enough temperature to keep burning. But when several logs are burned together, heat also flows from each log to the others and keeps the fire going. This explains why it is easy to start a fire with splinters or shavings.

The ignition temperatures of fuels differ. For a solid or liquid fuel to ignite, some of the fuel must first be heated to the temperature at which it *vaporizes* (turns to a gas). Solids generally have higher ignition temperatures than liquids because they vaporize at higher temperatures. For example, the ignition temperatures of most woods and plastics range from about 260° to 480° C. A liquid fuel such as petrol can ignite at a temperature as low as −38° C.

In addition, every fuel has two ignition temperatures. At one temperature, combustion can occur with the help of an outside energy source, such as a match. At another, higher temperature, combustion can occur spontaneously—that is, the fuel can start to burn without outside help.

How fires behave. A candle burning in a room without draughts produces a steady flame. The flame's heat vaporizes just enough candle wax to keep the flame burning at the same height.

Uncontrolled fires, on the other hand, fuel themselves by vaporizing the solid or liquid materials they find in their path. A house fire or forest fire may begin with easily ignitable materials. As the fire grows, it radiates more heat. The heat contributes to further growth, and the process accelerates as long as fuel and oxygen remain available. In a house fire, a phenomenon known as *flashover* occurs when all the surfaces in a room reach their ignition temperature. At this point, a relatively small fire suddenly ignites the remaining materials, filling the room with flames. In a forest fire, leaves, twigs, and other materials along the ground usually make up the fuel. But wind and certain types of terrain may cause a forest fire to spread along the tops of trees. Because fires can grow quickly and suddenly, professional fire fighters should immediately be called to control them. See **Fire brigade.**

We can control the fire in a furnace by regulating the supply of fuel and oxygen it receives. But only winds and the flow of air created by the fire regulate the rate of burning of an uncontrolled fire.

Fire used to be started by friction. This method consisted of whirling a stick in a notch as above, until a glow was produced.

Fireproof materials. The term *fireproof* suggests that a material has been treated with a substance that will prevent it from burning. But no material is truly fireproof. Even such incombustible materials as concrete and stone can become damaged by an intense fire.

Materials can, however, be treated with a *fire retardant* to reduce their ability to burn. Most fire retardants act to raise the ignition temperature of a material or to reduce the heat produced by combustion. Such treatments can slow combustion but they do not eliminate it. See **Fireproofing.**

Methods of starting fires. There are several methods of starting a fire, but in each of them the three necessary conditions for a fire must be present. Before matches were invented, the flint and steel method was used. This method required a piece of steel, a flint (hard rock), and a tinder. The tinder was generally made from cotton or linen cloth, or from dried, powdered bark from certain trees. It was heated in an oven until it was nearly ready to burn. It was then placed in a tinderbox to keep it perfectly dry. When the fire was to be started, tinder was placed on the ground and the flint struck against the steel. Some of the sparks made by the flint and steel would fly into the tinder and light it.

Another early method of starting fires was by friction. This method consisted of whirling a stick in a notch in a board until the wood powder that was produced began to glow. Enough oxygen to turn the glow into a blaze was supplied by blowing carefully on the glowing powder.

The first match was invented in 1827 by the English pharmacist John Walker. The tip of this match was coated with a mixture of antimony sulphide and potassium chlorate that was held onto the wooden matchstick by gum arabic and starch. When this tip was rubbed against a rough surface, friction produced enough heat to ignite the chemicals. The burning chemicals then produced enough heat to ignite the matchstick. Safer and more efficient matches were developed later. See **Match** (History).

What fire produces

Often the bottom of a pan or a skillet becomes black when it is placed over a fire. This discoloration occurs because of soot. Soot is primarily unburned carbon. The skillet becomes coated because it cools the flame, preventing the temperature from getting high enough to burn the fuel completely. If a furnace produces great quantities of soot, some of the carbon of the fuel is not being burned, and is wasted. This problem can be remedied by seeing that sufficient air is supplied to burn all the carbon in the fuel.

Gases. Substances that burn in air are nearly always composed of two elements, carbon and hydrogen, or their compounds. For example, coal, coke, and charcoal are mostly carbon. Natural gas, petrol, and fuel oils consist of many compounds of hydrogen and carbon. When these fuels burn, the oxygen of the air unites with the carbon and hydrogen to form carbon dioxide gas and water vapour. These usually mix with the air and disappear. The uniting of the oxygen with the hydrogen and the carbon produces the heat and flame of the fire.

Often, a deadly gas called carbon monoxide forms when there is not enough oxygen to burn the fuel completely. For example, when petrol burns in a car engine, some of this gas forms and comes out of the exhaust pipe. If you are in a closed garage when this happens, you may inhale this gas. Death may result. A person should never run the engine of a car in a closed garage.

Most people who are killed in fires in buildings die from inhaling carbon monoxide. Both smouldering fires and too little oxygen following flashover can promote the production of this gas.

Smoke is a mixture of soot and other particles with the gases produced by combustion. Smoke from fires can contain carbon monoxide and other poisonous gases. The soot and particles hamper vision and thus can make it difficult to escape from fires. In general, smoke results from incomplete combustion, which wastes energy and pollutes the environment.

Light. Most of the energy caused by a fire goes into heat, but some of it goes into light. The light results either because the carbon particles in the flame become so hot that they give off light energy, or because the gas that is burning is a type that gives off light.

Ever since fire was discovered, people have used it as a source of light. People first used flaming pieces of wood as torches. They later discovered that if the wood was dipped into pitch before lighting it, the light lasted longer and was much brighter. Years afterward, people poured oil in a dish, placed a wick in it, and lighted the wick. This gave a better light. Later, the tallow candle, which people could conveniently carry around, was invented. The paraffin lamp, with its chimney to help control the air currents, was a big improvement over the candle. After electricity was made usable, the American inventor Thomas A. Edison sent an electric current through a carbon *filament* (wire) until the filament became so hot that it gave off light.

Fire in legend and religion

Prehistoric people may have gained a knowledge of fire from observing things in nature, such as lightning, the fire of volcanoes, and the heat of the sun. They also must have noticed that sparks fly when stones are struck upon one another, or when the hoofs or claws of an animal strike some hard substance.

In Persian literature, there is a story of the discovery of fire in a fight with a dragon. One of the stones that the hero used as a weapon missed the monster and struck a rock. Light shone forth and human beings saw fire for the first time. The mythology of nearly all early peoples contains some account of accidental or supernatural happenings that first revealed fire to human beings. Early peoples regarded fire as a true gift of the gods.

Fire was considered sacred because it was so essential to the welfare of people. Fire worship and sun worship have existed since very early times. Because fire was so hard to produce, the custom soon became common of keeping a public fire, which was never allowed to die out. These fires were kept in every village among the Egyptians, Persians, Greeks, and Romans. They were often in the civic centre of the community.

The Temple of Vesta in Rome was an outstanding example of the importance of fire to the Romans. Vesta was originally the goddess of the hearth, and her shrine was in every home. But when religion became an affair of state, a temple was erected in which the sacred fire was kept burning at all times. See **Vesta.**

Related articles in ***World Book*** include:

Camping (Building a campfire)	Fire brigade	Fireproofing
Combustion	Fire extinguisher	Match
	Fire prevention	Prometheus

Fire alarm. See Fire brigade.

Fire ant is any of several species of ants that inflict painful, burning stings. Five species of fire ants are to be found in the Southeastern United States. One of these, the red imported fire ant, is a major pest. Red imported fire ants build large earth mounds that measure up to 0.6 metre high. The mounds are so hard they can damage farm machinery. Hundreds of thousands of fire ants may inhabit one mound. If a person or animal disturbs the activities of a mound, the ants swarm out to attack the intruder. The red imported fire ant's sting leaves a small, pus-filled, itchy bump that is easily infected. Some people experience severe—in rare cases, fatal—reactions to fire ant venom.

Red imported fire ants range in colour from red to brown, and measure about 6 millimetres long. This species is native to South America. It probably entered the United States aboard freight shipped through Mobile, Alabama, U.S.A., during the 1930's. It has since spread rapidly and now inhabits an area that stretches from southern North Carolina to central Texas, U.S.A.

In the 1980's, scientists developed fire ant baits that contain soybean oil to attract the insects. An ingredient in the baits disrupts development of fire ant larva. Such baits may help control the population of fire ants.

The four other species of fire ants in the Southeastern United States do not pose major agricultural or health problems. Three of these species are native to this region. The fourth—the black imported fire ant—is a South American species that probably entered the United States in 1918.

Scientific classification. Fire ants belong to the order Hymenoptera. The red imported fire ant is classified as *Solenopsis invicta.*

Fire blight. See Pear (Diseases); **Blight.**

Fighting fires is one of the most important tasks of a fire brigade. Many fire fighters and a variety of equipment are needed to put out a large building fire, such as the one shown above.

Fire brigade

Fire brigade is one of the most important organizations in a community. Fire brigades, or fire departments, battle fires that break out in homes, factories, office buildings, stores, and other places. Fire fighters risk their lives to save people and protect property from fires. They have one of the most dangerous of all occupations.

The men and women who work for fire brigades also help people in many kinds of emergencies besides fires. For example, they rescue people who may be trapped in cars or trains after an accident. They aid victims of such disasters as tornadoes and floods.

Fire brigades work to prevent fires by enforcing fire safety laws. They also teach people about possible fire dangers in their homes and places of work. People cause most fires through carelessness. They could prevent these fires if they knew about fire hazards and followed certain safety measures. Every year in Britain, fires kill about 1,000 people, injure about 11,000 others, and destroy valuable property. To reduce the damage caused by fires, local fire brigades need the support of the people in the community.

The work of a fire brigade

Fire fighting. The two basic fire-fighting appliances, or engines, used by fire brigades are trucks called *pumpers,* which carry a pump and hoses for spraying water onto a fire, and *ladder trucks,* which carry an extension ladder or elevating platform to rescue people through the windows of buildings. Fire-fighting appliances also have other rescue equipment and fire-fighting tools. Other fire brigade vehicles include *foam tenders,* which are used to fight chemical and oil fires. In most large cities, each fire station has at least one pump engine and one ladder truck. At a fire, the fire fighters work together as a team under the direction of an officer.

Fire brigades must handle many types of fires. Each type requires a different plan of action to put it out. For example, the methods used to fight a building fire differ greatly from those used to fight a forest or grassland fire. The following discussion describes how fire fighters battle the two types.

Fighting a building fire. After an alarm is received, the fire brigade speeds to the fire. The fire engines often arrive within a few minutes of receiving the alarm. The officer in command quickly sizes up the situation and directs the fire fighters into action.

Fire fighters first connect a hose from the pump to a nearby fire hydrant. They then stretch hose lines from the pump to the building on fire and try to locate the fire within the building. Their first concern is to keep the fire from spreading. The fire fighters spray water on any nearby buildings that are in danger of catching fire. They then direct water on the fire itself until it is out.

Meanwhile, other fire fighters search for people who may be trapped in the building. In some buildings, they use ladders to rescue people through windows. However, not even an extending hydraulic platform ladder can reach up beyond about eight storeys of a tall building. Fire fighters must use lifts or stairs to get to persons trapped on floors above the reach of the ladders.

Fire fighters must also ventilate the building to let out the smoke, heat, and gases that build up during a fire. They open or break windows and sometimes cut holes

in the roof or walls. If the building were not ventilated, the heat and the pressure of the gases could cause an explosion. They may have to wear breathing apparatus for protection against smoke and fumes.

The fire fighters try to save any furniture or other property not damaged by the fire. They spread canvas or rubber covers over such property to prevent water damage. Finally, they search the building for hidden sparks that might cause another blaze. They soak the ashes to make sure the fire really is out.

After the fire is out, the fire fighters try to find out exactly where and how the fire started. The officer in charge makes out a report that gives all the important facts about the fire. The report includes information on the number of persons killed, if any; the cause of the fire; and the estimated cost of damage.

Fighting a grassland or forest fire. Many grassland and forest fires occur in areas that are hard to reach and far from a source of water. Local fire brigades have trucks that carry water and can travel over rough land. Observers in helicopters or aeroplanes may fly over the fire and report on its size and behaviour. Sometimes, helicopters or aeroplanes are also used to carry fire fighters to the fire or to drop chemicals that slow the spread of the fire.

Grassland and forest fires often spread rapidly and are difficult to put out. Fire fighters try to keep the fire within the smallest area possible, and so they may first create a *firebreak,* or *fireline.* The fire fighters clear a strip of land some distance in front of the racing flames. They cut down the grass or trees and scrape away some of the soil with shovels or a bulldozer. The fire fighters may then set a *backfire* to burn the area between the firebreak and the onrushing fire. The firebreak and the backfire prevent the flames from spreading. After the fire has been contained, the fire fighters spray water or throw soil on the flames until the fire is out.

Emergency rescue operations. Fire brigades also handle nonfire emergencies. For example, fire fighters may be called upon to free people trapped under the wreckage of a collapsed building or in a car after an accident. Rescue workers sometimes have to break through walls or cut through metal doors to reach an injured person.

In some countries, fire brigades have *paramedic units,* which give on-the-scene medical care in an emergency. Fire fighters trained as paramedics treat heart attack victims and other persons needing emergency attention. The paramedics operate ambulances that carry medical equipment, drugs, and a two-way radio for contact with a nearby hospital. See **Paramedic.**

Fire prevention and fire safety. To help prevent fires and reduce fire losses, local fire brigades inspect public buildings and private homes. They also teach people about fire safety and conduct *arson* investigations. Arson is the crime of deliberately setting fire to a building or other property.

Public building inspections. Most cities have a fire safety code that applies to such buildings as theatres, department stores, schools, and hospitals. Under these codes, the buildings may not be constructed of materials that burn easily. The codes also require portable fire extinguishers, a certain number of exits, and other fire safety features in public buildings.

Fire brigade officials inspect public buildings from time to time to enforce the local code. The officials check the condition of the electrical equipment and the heating system. They note the number and location of exits and fire extinguishers. The inspection also covers housekeeping conditions and many other matters that affect fire safety. Fire brigade inspectors may also review plans for a new building to make sure it meets the safety code.

Home inspections. Most of the deaths caused by fires occur in private homes. For this reason, many fire brigades have home safety programmes. They will send a fire fighter to inspect a private home if asked by the owner. After the inspection, the fire fighter recommends ways to make the home safer from fire.

During home inspections, fire fighters check such things as heating and air-conditioning systems and the cooking equipment. They look for unsafe practices, such as overloading electrical outlets or running electrical wires under a rug. The fire fighters also instruct families on what to do if a fire breaks out. To leave the home safely and quickly in case of fire, families are advised to make escape plans and to practise fire drills. For other recommendations, see the table *What to do in case of fire* on this page.

Most fire prevention experts advise people to install *smoke detectors* in their homes. Smoke detectors are devices that sound an alarm if smoke builds up in a room. The devices are atttached to the ceiling or wall in several areas of the home. Most home fires that result in deaths occur at night when the family is asleep. Smoke detectors will awaken the family before the fire and the smoke build up to the point where escape is impossible. *Heat detectors,* which sound an alarm if the temperature rises to a certain point, are also available. However, smoke detectors generally give an earlier warning than do most heat detectors.

Another sensible precaution is for people to have portable fire extinguishers in their homes. A person must be sure, however, to use the right kind of extinguisher for the type of fire involved. For example, a water extinguisher cannot put out an oil fire. Such a fire must be fought with a special gas extinguisher. For more information on the kinds of fires and extinguishers, see the article **Fire extinguisher.**

What to do in case of fire

1. **Leave the building immediately.** Do not try to fight the fire unless it is confined to a small area.
2. **Never open a door that feels hot.** Before opening any door, place your hand on it. If the door feels hot, the fire on the other side may be blazing fiercely. You could be killed by the heat and smoke if you opened the door. Try another escape route or wait for help.
3. **Crawl on the floor when going through a smoky area.** Smoke and heated gases tend to rise, and so they will be thinnest near the floor.
4. **Do not run if your clothes catch fire.** Running fans and spreads flames. Roll on the floor to smother the flames.
5. **Do not return to the building for any reason.** After you have escaped, call the fire brigade. If people are still trapped in the building, wait for the fire brigade to rescue them.

Public education. Many fire brigades work with other local agencies to teach people how to prevent fires and what procedures to follow during a fire. In some communities, fire brigade officials serve as instructors or advisers in fire safety courses in schools. They also supervise school fire drills.

Arson investigations. Specially trained fire investigators gather evidence in cases where arson is suspected. Fire brigade officials in some cities estimate that nearly half the fires in their cities are started deliberately.

Fire brigade equipment

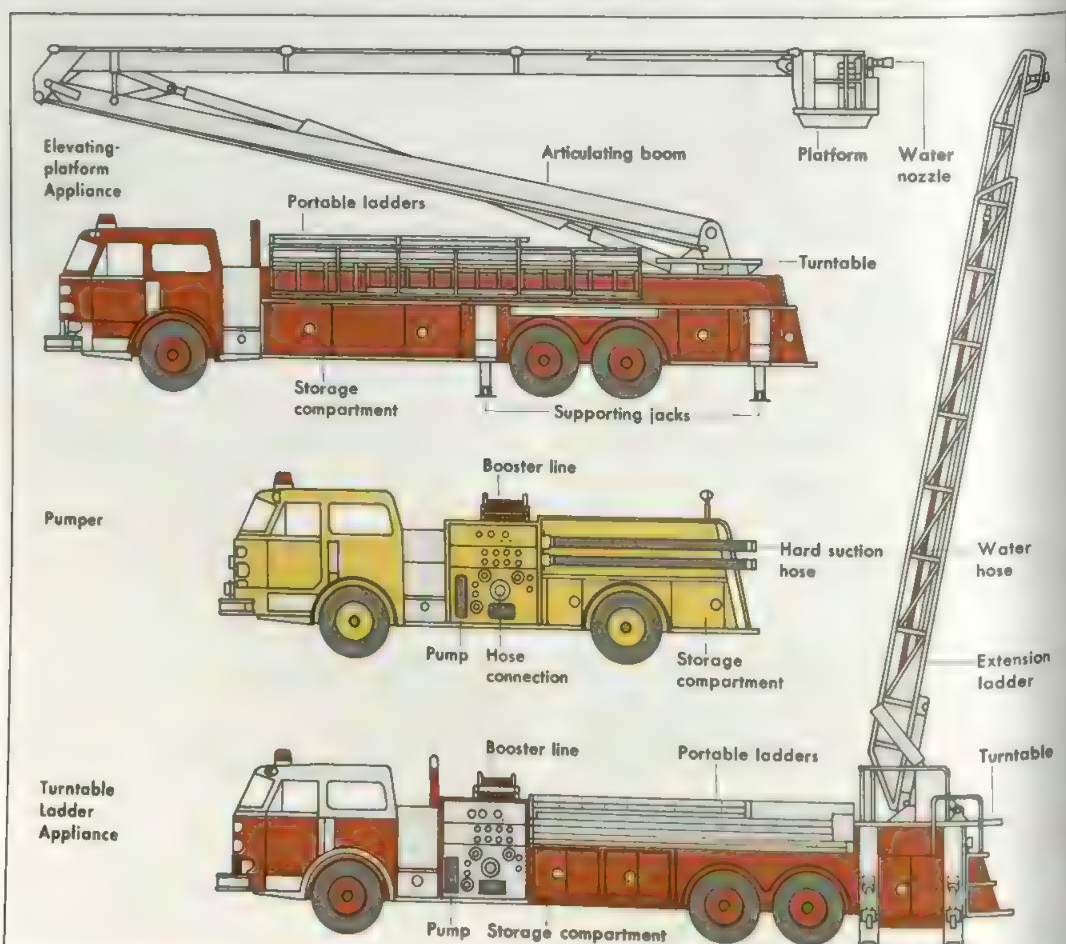
The most important equipment of a fire brigade includes (1) communication systems, (2) fire appliances, and (3) special fire vehicles. In addition, the fire fighters themselves require protective clothing.

Communication systems are necessary to alert fire stations to the outbreak of a fire. Most fire alarms reach the fire station after an emergency telephone call. Other alarms are sent by automatic signalling boxes, or in some countries from fire alarm boxes situated on street corners.

Emergency telephone calls are directed to the central control room of the area fire brigade. From there, a message is sent, by teleprinter or computer, to the fire station nearest the fire. The message gives the location of the fire, and the route to get there. Within a few seconds of receiving the message, the fire fighters can be on their way to the fire.

Automatic signalling devices are installed in many public buildings. These devices include smoke and heat detectors that are wired to send an alarm automatically to alarm headquarters. A *sprinkler system* can also be wired to alert the fire brigade automatically. Such a system consists of a network of pipes installed throughout a building. The pipes carry water to nozzles in the ceiling. The heat from a fire causes the nozzles directly above the fire to open and spray water. When the water starts to flow through the pipes, an alarm is automatically sent to the fire brigade.

Three kinds of fire appliances The illustrations below show an elevating-platform appliance, a pumper, and a turntable-ladder appliance. All three appliances are used to spray water on a fire. Elevating-platform and turntable-ladder appliances can also be used to rescue people through the windows of a burning building.



After fire fighters arrive at a fire, they advise headquarters how serious the situation is and, if necessary, ask for more help. With each call for additional help, more equipment and fire fighters are sent to the fire. Each fire appliance has a two-way radio for communication with headquarters.

Fire appliances. Fire brigades have several types of fire appliances, or engines. The main kinds are (1) pumpers, (2) ladder appliances, and (3) rescue appliances.

Pumpers carry about 1,000 litres of water, and have a large pump that takes extra water from a fire hydrant or other source. The pump boosts the pressure of the water and forces it through hose lines. The pump size is determined by the amount of water it can discharge per minute. The most powerful pumps can deliver more than 5,000 litres of water per minute.

Pumpers carry several sizes of hoses and nozzles. Many pumpers also have a small-diameter hose called a *booster line,* which is wound on a reel. The booster line is used chiefly to put out small outdoor fires. Pumpers used for fighting grass or brush fires carry such tools as shovels and rakes. Many pumpers also carry ladders.

Ladder appliances. There are two kinds of ladder appliances—*turntable ladder* and *elevating platform.* A turntable ladder appliance has a metal extension ladder mounted on a turntable. The ladder can be raised as high as 30 metres, or about eight storeys. An elevating-platform appliance, or hydraulic platform vehicle, has a cagelike platform that can hold several people. The platform is attached to a lifting device, either an *articulating boom* or a *telescoping boom,* which is mounted on a turntable. The boom on the largest appliances can extend more than 45 metres. A built-in hose runs the length of the boom and is used to direct water on a fire.

These vehicles are equipped with portable ladders, stretchers, and first-aid kits. They also carry *forcible entry tools* to break into a building or a room. These tools include axes, power saws, and sledge hammers.

Rescue appliances are enclosed vehicles equipped with many of the same kinds of forcible entry tools that are carried on ladder appliances. But rescue appliances also carry additional equipment for use in unusual rescues. They have such tools as oxyacetylene torches, for cutting through metal, and hydraulic jacks, for lifting heavy objects. They also carry scuba gear, fire-resistant suits, and emergency medical supplies and equipment.

Special fire vehicles include *airport foam tenders* and *fireboats.* Airport foam tenders are pumpers that spray foam or dry chemicals on burning aircraft. Water is ineffective against many aircraft fires, such as those that involve aviation fuel, petrol, or certain aircraft metals. Fireboats fight fires on ships and piers and in waterfront buildings. These boats have pumps that draw water from a river, lake, or sea. Large seagoing fireboats can pump about 38,000 litres of water per minute.

Protective clothing. Fire fighters require special clothing for protection against flames, falling objects, and other hazards. They wear jackets made of fire-resistant material and protective trousers. Other clothing includes specially made boots, gloves, and helmets, and special suits for use in chemical fires. Fire fighters also use masks to avoid inhaling smoke and toxic gases. The masks are connected to small air cylinders strapped on the back.

Some equipment carried on fire appliances

Fire appliances carry a variety of *forcible entry tools,* such as axes and crowbars, which are used to break into a building or a room. Other equipment on fire appliances includes first-aid kits, air cylinders and masks, and powerful fans.

Fire fighters require special clothing for protection against flames, smoke, and other hazards. They wear fire-resistant jackets and trousers, and special boots, gloves, and helmets. Masks are used to avoid inhaling smoke and toxic gases.

A turntable ladder is a metal extension ladder mounted on a turntable. The ladder can be raised about 30 metres.

On certain rare occasions, fire fighters must walk through flames. For instance, they may have to do so when rescuing passengers from a burning aeroplane. They then wear *heat-reflective suits.* These suits are fire resistant and coated with aluminium to reflect heat. They cover the whole body, leaving no part unprotected.

Kinds of fire brigades

The main kinds of fire brigades are (1) full-time, (2) volunteer, and (3) special purpose.

Full-time fire brigades. Most cities and large towns have their own full-time fire brigades, which can respond quickly in the event of a fire.

In the United Kingdom, regulations and standards for the training, equipping, and operation of fire brigades are set by government ministers in consultation with the Central Fire Brigades Advisory Council. The provision and financing of adequate and properly equipped fire brigades is the responsibility of the local authorities. Each local authority appoints a chief fire officer, who controls the fire brigade from a central brigade headquarters. The area covered by the brigade is split into divisions. Each division has a divisional officer. This officer leads the brigade contingent that is called out to fight a fire in its division. A division that is fighting a fire can receive help promptly if it cannot control the fire on its own. Altogether, there are about 40,000 full-time and 21,000 part-time fire fighters in the United Kingdom.

In the Republic of Ireland, fire brigades are paid for by the county and county borough administrations. They are run by the local authorities. Altogether, there are about 1,100 full-time fire-fighters and 2,000 part-time fire fighters.

In Australia, fire brigades are controlled by state governments within their own states and by the federal government in the territories. Insurance companies meet three-fourths of the costs of fire fighting and state and local governments meet the rest. A Fire Service Commission controls fire brigades in New Zealand, where government and insurance companies also meet the cost.

Volunteer fire brigades provide protection mainly in small towns and rural communities. They are staffed by men and women who serve part time. Some brigades have a few paid fire fighters but rely mainly on volunteers. When a fire breaks out in the community, the volunteers leave their jobs or homes and rush to the fire station. In some brigades, the volunteers are paid for their work, but in others they receive no pay. Britain has about 50,000 volunteer fire-fighters, fewer than in many other countries.

Many volunteer fire brigades have only enough equipment and volunteers for routine fires. During a major fire, neighbouring communities help one another.

Special-purpose fire brigades are maintained by certain government departments and some private industries. Governments maintain fire fighting units at all military bases and other large installations. These units are trained to handle fires and other emergencies unique to a particular installation, as well as routine fires. For example, fire fighters on air force bases are

Heat-reflective suits are worn by fire fighters in special cases when they have to walk through flames. The suits are fire resistant and coated with aluminium to reflect heat

Bushfires threaten lives and damage property in bushland areas close to such large cities as Sydney. Volunteer bushfire brigades fight many blazes in Australia each summer, especially in country areas.

trained to put out aircraft fires, and fire fighters at nuclear power installations are trained to deal with radiation emergencies. Special fire-fighting units watch for and put out forest fires. In Australia, volunteers are organized into *bushfire brigades* to fight the many forest fires that occur each year.

Some industrial plants, such as those that manufacture fuels or explosives, organize their own fire-fighting teams. In addition, all major airports have a fire brigade to fight aircraft fires.

History

One of the first fire-fighting organizations was established in ancient Rome. Augustus, who became emperor in 27 B.C., formed a group called the *vigiles*. The vigiles patrolled the streets to watch for fires. They also served as the police force in Rome.

Scholars know little else about the development of fire-fighting organizations in Europe until after the Great Fire of London in 1666. This fire destroyed much of the city and left thousands of people homeless. Before the fire, London had no organized fire protection system. After the fire, insurance companies in the city formed private fire brigades to protect their clients' property. Each company's brigade attended only premises bearing the company's *fire mark,* a metal plate fixed to the building. In the 1830's, the insurance companies cooperated to set up a single London Fire Brigade Establishment. This was Britain's first fully centralized fire brigade. It fought fires in any premises within the London area. This was succeeded by the Metropolitan Fire Brigade, which was founded in 1866. This brigade was the forerunner of today's fire brigades.

In the mid-1800's, steam pumpers pulled by horses began to replace the hand pumps formerly used. The steam pumpers required fewer people to operate them. During the early 1900's, steam pumpers were replaced by petrol- or diesel-engined fire engines. Since then, many improvements have been made in the equipment and methods used in fire fighting.

Recent developments. During the 1970's, the governments of many countries encouraged their fire brigades to devote more time and money to fire prevention activities.

Since the 1960's, many fire brigades have been faced with drastic increases in arson. Between the mid-1960's and 1977, the arson rate in the United States, for example, increased by about 300 per cent. In an effort to reduce the problem, some fire brigades have increased the number of arson investigators and have pushed for stronger laws against arson.

False alarms have also become a serious problem. In some cities, a third or more of all alarms received by the fire brigade are false alarms.

A number of fire brigades now employ female as well as male fire fighters. Women had served in volunteer fire brigades since the 1800's, but have only been recruited as professional fire fighters since about the 1970's.

Study aids

Related articles in ***World Book*** include:

Arson
Bushfires
Fire
Fire extinguisher
Fire marks
Fire prevention
Fireproofing
Forestry (Fire)
Paramedic
Safety
Smoke detector
Thermography

Outline

I. The work of a fire brigade
- A. Fire fighting
- B. Emergency rescue operations
- C. Fire prevention and fire safety

II. Fire brigade equipment
- A. Communication systems
- B. Fire appliances
- C. Special fire vehicles
- D. Protective clothing

III. Kinds of fire brigades
- A. Full-time fire brigades
- B. Volunteer fire brigades
- C. Special-purpose units

IV. History

Steam pumpers pulled by horses were used by fire brigades from the mid-1800's to the early 1900's. At the time, they were a major improvement over the hand pumps formerly used.

Questions

What rules should a person follow in the case of a fire?
How were the first fire brigades organized?
What is the purpose of firebreaks and backfires?
Why do fire brigades inspect buildings and homes?
What are foam tenders used for?
How do smoke and heat detectors work?
Why must fire fighters ventilate a burning building?

Fire engine. See **Fire brigade** (Fire brigade equipment; Picture: Three kinds of fire appliances).

Fire extinguisher is a metal container filled with water or chemicals used to put out fires. Fire extinguishers are portable and easy to operate, and can be used to put out small fires before the flames spread.

There are many kinds of fire extinguishers. The kind used depends on the type of fire involved. Fire prevention experts divide fires into four classes—A, B, C, and D—depending on the burning material. *Class A* fires involve such ordinary combustible materials as cloth, paper, rubber, or wood. *Class B* fires involve flammable gases or such flammable liquids as cooking fat, oil, or petrol. *Class C* fires involve motors, switches, or other electrical equipment through which electric current is flowing. *Class D* fires involve combustible metals, such as magnesium chips or shavings. Most fire extinguishers are labelled with the class, or classes, of fire for which they can be used.

Class D fires require special extinguishers designed for specific metals. But most other fire extinguishers can be classified, by their contents, as one of four types: (1) water, (2) foam, (3) liquefied gas, and (4) dry chemical.

Water extinguishers are used to fight only class A fires. Water conducts electricity, and so it must never be used on a fire involving electrical equipment. A water extinguisher is operated by a lever or a hand pump that shoots the water through an attached hose.

Foam extinguishers are used for class A and class B fires. A foam extinguisher contains water and a foaming agent. One type of foam puts out fires that involve combustible liquids by depositing a film between the liquid and the flame.

Liquefied gas extinguishers may be used on class B and class C fires. There are two main kinds—*carbon dioxide extinguishers,* which contain carbon dioxide gas; and *Halon extinguishers,* which contain a gas called *Halon.* Larger Halon extinguishers can also be used to fight class A fires. Both carbon dioxide extinguishers and Halon extinguishers have the gas in liquid form under pressure in the container. When the operator squeezes a handle, the liquid flows out of the container and becomes a gas that covers the fire. Liquefied gas extinguishers leave no water or powder. For this reason, the gas types are the most suitable for class C fires involving computers or other delicate electrical equipment that could be damaged by other types of extinguishers.

In 1992, more than 85 nations agreed to ban the production of Halon by Jan. 1, 1994, because Halon harms the ozone layer in the earth's upper atmosphere. This layer of ozone protects plants and animals from most of the sun's ultraviolet rays. The agreement, which also al-

Kinds of fire extinguishers

The chief kinds of fire extinguishers are *water, foam, liquefied gas,* and *dry chemical.* To operate most extinguishers, a person pulls the locking pin and squeezes the operating lever while aiming the nozzle at the base of the fire and moving the nozzle with a sweeping motion across the fire's base.

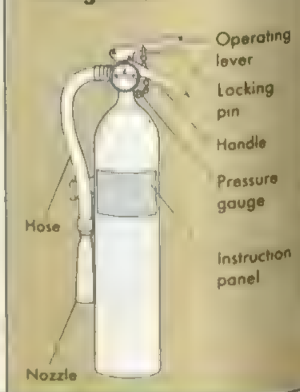
Water extinguishers are filled with water. They are used to fight class A fires, which involve wood, paper, cloth, or other combustible solids. Water extinguishers must never be used for fires that involve electrical equipment.

Foam extinguishers contain water and a foaming agent. They are used for class A fires and for class B fires. Class B fires involve flammable gases or such flammable liquids as petrol or cooking fat.

Liquefied gas extinguishers contain either carbon dioxide gas or a gas called *Halon.* They are used for class B fires and for class C fires, which involve electrical equipment through which electric current is flowing. Larger Halon extinguishers are also used for class A fires.

Dry chemical extinguishers contain a chemical powder. They are used on class B or C fires. A type called multipurpose dry chemical can also be used on class A fires.

Parts of a fire extinguisher



lowed for the continued use of stored or recycled Halon, was an amendment to the 1987 Montreal Protocol on Substances That Deplete the Ozone Layer.

Dry chemical extinguishers are used on class B and class C fires. One type, the *multipurpose dry chemical extinguisher,* also can be used against class A fires. Dry chemical extinguishers contain a chemical powder and a gas under pressure. The gas may be stored either with the powder in the extinguisher's main compartment or by itself in a separate cartridge or cylinder. If the gas is stored separately, the user must enable the gas to flow into the main compartment before the extinguisher can be used. The user does this by turning a valve or by operating a lever that punctures the gas compartment.

Fire fighting. See Fire brigade (Fire fighting).

Fire marks are metal plates that British insurance companies used to put on buildings that they insured against fire. Each company maintained its own fire brigade in order to safeguard the property it insured. If one insurance company's brigade arrived at a fire and found, by looking at the fire mark, that another company insured the building, it did not fight the flames.

Fire marks were placed on houses to show that they were insured against fire.

Fire marks were made of lead, copper, or iron. They were fixed on the front of an insured building, generally between the first-floor windows. They bore the name or symbol of the company, and many were elaborate in design. They were first used in the 1660's, after the Great Fire of London.

Fire prevention is a term for the many safety measures used to keep harmful fires from starting. Fires not only cause extensive damage to valuable property, but are responsible for large numbers of deaths. In 1992, 425,000 fires were reported to fire brigades in the United Kingdom (UK). The fires caused 789 deaths and more than 14,700 injuries. The total cost of fires in the UK in 1992 was more than 850 million pounds. In the United States, about 6,000 people are killed every year as a result of fire. A further 28,000 are injured and damage to property costs an estimated U.S. $7 billion.

Individuals, groups, and communities use three main methods to prevent fires: (1) laws and regulations, (2) inspection of buildings and other property, and (3) public education about fire safety and prevention.

Most countries have codes and standards that require certain types of fire retardant materials and electric wiring to be used in buildings. Fire brigades and other public agencies inspect public buildings for fire hazards and recommend corrective action. In some communities, homeowners may agree to have their homes inspected for fire hazards. Education is a vital part of fire prevention programmes because people cause—and could prevent—almost all fires. Fire brigades, community groups, and schools teach children and adults about fire hazards and work to reduce fires throughout the community.

A flammability test determines how fast a substance burns. This scientist is measuring the speed at which fire travels on the surface of a material that has been ignited inside a tunnel.

In homes and schools, rubbish, old clothes, curtains, and furniture should be discarded, not stored in attics, basements, or cupboards. They could quickly catch fire in those places. Such liquids as petrol and paint burn easily and should be stored in tightly closed containers, away from heat. Petrol should not be stored indoors, and it must never be used to start a barbecue or bonfire.

In old homes and schools, an electrician should regularly check electrical wiring and replace any that appears weak or worn. An electrician should also replace cords on electric appliances as soon as the outside coverings become worn. Cords should never be run under carpeting, where they might become damaged and set the carpeting on fire. A fire can also result from overloading one outlet with several appliances. See **Safety** (Safety at home; Safety at school).

Many types of fabric burn easily. Wise parents teach children to avoid clothing fires by not standing close to cookers or bonfires and not playing with matches.

Many school programmes train children to be alert to fire hazards. Young children may learn these dangers by colouring sheets of pictures, rhymes, and slogans about fire prevention. Many older children visit fire departments. Fire fighters or teachers may also give talks and demonstrations for classes and assemblies.

In the community, fire brigades and other public agencies work to improve fire prevention through laws, inspections, and educational programmes. Such groups as chambers of commerce and youth clubs promote fire prevention through newspapers, pamphlets, posters, and radio and television appeals.

Some groups sponsor programmes to alert the community to fire hazards that occur during various seasons.

For example, the number of fires in homes increases every winter, when heating equipment comes into use. Some of this equipment has not been kept in good condition or has been misused. In many communities, organizations put safety tags on Christmas trees which are known to burn very easily.

Local clean-up weeks encourage homeowners, shops, and factories to discard rubbish and eliminate other fire hazards. Most communities have laws that require regular inspections of commercial, public, and some residential buildings. Fire brigade officials are appointed to conduct inspections of such premises for fire dangers.

In the U.K., a National Fire Safety week is held in October each year. The week is devoted to focusing public attention on the dangers of fire and on the steps that can be taken to minimize them.

In industry, fire prevention presents special problems because fire must be used for so many jobs. Fire performs such tasks as melting metals, heating chemicals, and generating electricity. Machines and furnaces used for these jobs must be carefully designed to keep the flames under control. Inspectors check for fire hazards near machines and in other areas of a factory. Employers teach workers to operate machines safely and to report any problems that could cause fire.

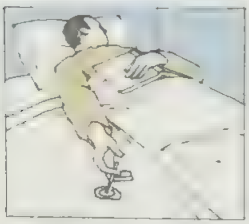
Workers in factories and workshops must take special care when using dry or liquid chemicals and oils. Some liquids give off easily ignited vapours and have to be stored in metal safety containers. Spilled chemicals, and dust and chips from flammable materials, must be cleaned up immediately.

Many industries sponsor special classes and demonstrations to teach workers how to prevent fire at their place of work. Factory bulletin boards, pamphlets, and articles in company magazines also promote fire safety at work.

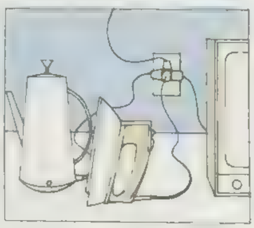
Fire prevention laws began with building regulations established in ancient times. About 18 B.C., the Roman Emperor Augustus set maximum heights for

Fire hazards in the home

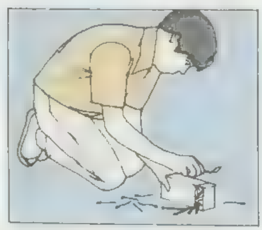
Many fires start in homes, and most are caused by carelessness. These pictures show careless habits that can result in fire.



Smoking in bed can cause linen or clothing to catch fire if the smoker falls asleep.

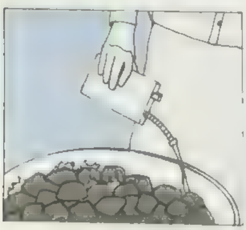


An overloaded electrical outlet can cause overheated wires to burn.

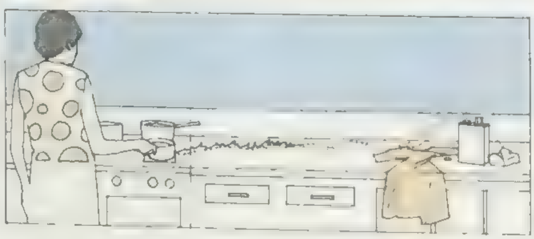


Playing with matches can result in rugs, clothing, and other items being set aflame.

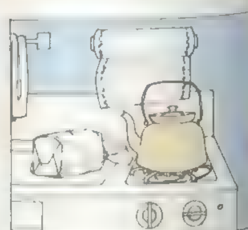
Storing flammable liquids near a boiler can cause escaping fumes to catch fire.



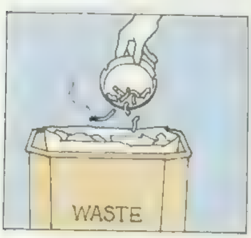
Petrol should not be used to start fires. It is too flammable and uncontrollable.



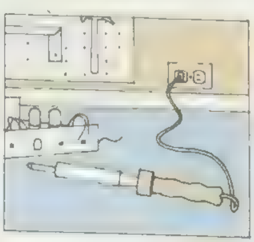
A flashback fire can begin when fumes escape from cleaning fluid or some other flammable liquid and come in contact with a flame. A flashback fire travels along the path of the fumes.



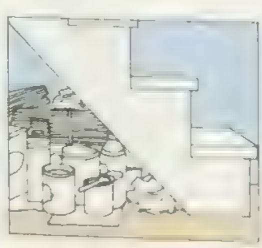
Dish towels and other burnable items can be set ablaze if placed too near a cooker.



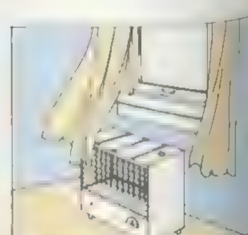
Throwing away cigarettes that are still burning can start a wastebasket fire.



A soldering iron can set a workbench on fire if not disconnected after being used.



Stored rags soaked with grease, oil, or paint can quickly burst into flame.



Space heaters located too close to blowing curtains can cause the fabric to catch fire.

houses and minimum thicknesses for their walls. Later laws required minimum separations between buildings to prevent fires from spreading from one structure to the next. In the A.D. 300's, Emperor Julian issued controls on the work of blacksmiths and other tradespeople who used fire. For example, he banned smoking chimneys that could cause roof fires. Princes in parts of Italy and Germany used some of these laws as late as the 1600's.

In the American Colonies, the earliest fire laws dealt with fighting, rather than preventing, fires. But newspapers sometimes advised readers about fire hazards. Since then, public education programmes have become important supplements to fire prevention laws and inspection programmes. Many such programmes operate throughout the year.

Australia, the Netherlands, Sweden, and the United Kingdom also stress public education in fire prevention. But most industrialized nations rely more on laws, inspections, and worker training.

In many countries, insurance requirements form the basis of fire prevention programmes. In the U.K., the Fire Protection Association (FPA) is the national fire safety organization, and is one of 20 similar organizations worldwide. The FPA is a part of The Loss Prevention Council, a U.K.-based organization involved in all aspects of loss prevention and control on a worldwide basis.

See also **Combustion; Fire brigade; Fire extinguisher; Fireproofing.**

Fire worship is an ancient religious practice based on the idea that fire is sacred. Since early times, people have worshipped fire because it destroys, purifies, and gives heat and light. Some people believe a god or spirit inhabits fire. The Parsees of India and other followers of a religion called Zoroastrianism use fire as a divine symbol. The ancient Greeks and Romans considered fire one of the major elements that made up the world. Some American Indians lit fires when the new year began. Today, many people build bonfires on various occasions. This practice probably developed from the ancient tradition of fire worship.

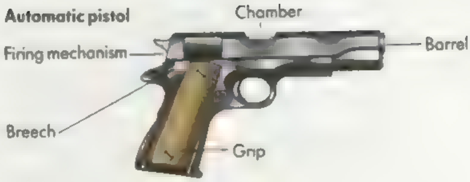
See also **Parsees; Vesta.**

Firearm is any weapon that uses gunpowder to fire a bullet or shell. Generally, the term is used for light firearms, such as rifles, shotguns, and pistols. They are often called *small arms.* Heavier firearms are generally referred to as *artillery.*

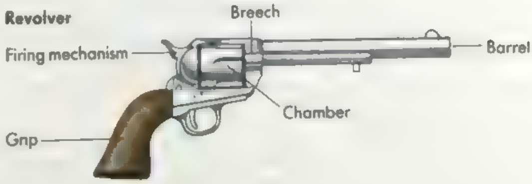
Mechanism. Any firearm, large or small, has four essential parts: (1) barrel, (2) chamber, (3) breech mechanism, and (4) firing mechanism. The *barrel* is a long tube. It may be smooth, as in a shotgun, or with spiral grooves on the inner surface, as in a rifle. The *chamber* is a widened hole at the *breech* (rear) end of the barrel. It holds the *cartridge* (explosive charge). The *breech mechanism* closes the rear end of the barrel, holding the cartridge in the chamber. Every modern firearm has some way by which the breech can be opened for loading and locked for safety in firing. Artillery uses screw plugs or breechblocks. Machine guns, rifles, and other small arms usually have a metal cylinder, or *bolt,* that is locked when the gun is fired, and drawn back to eject the empty cartridge case and to reload. The *firing mechanism* may be electric, as in some large artillery pieces. In small arms, a spring drives a pointed firing pin through the breech bolt against a sensitive *primer* in

Types of firearms

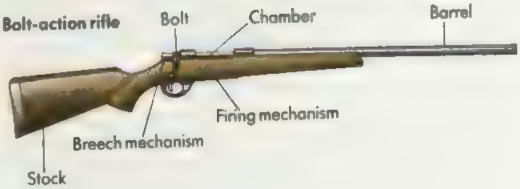
Automatic pistol



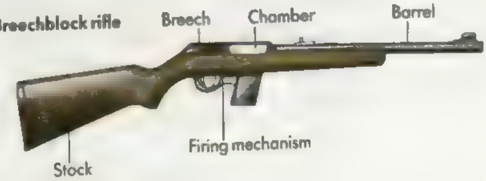
Revolver



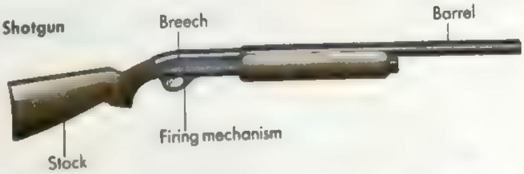
Bolt-action rifle



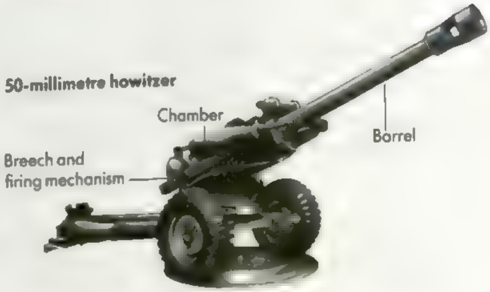
Breechblock rifle



Shotgun



50-millimetre howitzer



the cartridge. The firing pin is *cocked* (drawn back) against a hook called the *sear.* When the trigger is pulled, the sear releases the firing pin, which in turn leaps forward to strike the primer. A jet of flame from the primer ignites the rest of the powder in the cartridge, forming a gas. This explosive gas propels the bullet from the barrel.

In World War I (1914-1918), British and Commonwealth soldiers carried the Lee-Enfield repeating rifle, first introduced in 1902. This rifle, which had a magazine holding 10 cartridges, continued in use during World War II (1939-1945).

History. Europeans first learned of gunpowder in the 1200's. By the 1300's, they had discovered that it could be used to propel an object with great force. Firearms as we know them were then developed. The first firearms were cannons, but people soon developed firearms that they could carry.

The invention of firearms led to great changes in warfare. Bullets could penetrate armour. Castles had easily withstood the attacks of people armed with battle-axes, swords, spears, and bows and arrows. But they crumbled before the assault of new weapons such as cannons. Soldiers used pistols, blunderbusses, and muskets. They had to load their hand-held firearms from the muzzle, and found these weapons heavy and clumsy. But, clumsy as they were, they revolutionized warfare.

The rifle was invented in about 1500. It had spiral grooves, or *rifling,* inside the barrel that caused the bullet to spin in its flight. This made the rifle more accurate than any previous firearm. Smokeless powder was developed in the 1800's. Breechloading systems replaced dangerous muzzle loading. Later developments were the repeating rifle, the machine gun, and automatic and semiautomatic rifles and pistols.

Related articles in *World Book* include:

Ammunition	Cannon	Gun	Mortar
Armour	Carbine	Handgun	Musket
Artillery	Explosive	Harquebus	Rifle
Bazooka	Flintlock	Machine gun	Shotgun
Blunderbuss	Garand rifle		

Fireball is a meteor that burns brightly as it plunges through the earth's atmosphere. If the fireball explodes at the end of its path, it is generally called a *bolide.* Some pieces may survive the explosion, and fall to the earth. Only brightness makes a fireball different from an ordinary meteor. A fireball is as bright as Jupiter or Venus. In rare cases, it may be as bright as the full moon. A sound like thunder occasionally accompanies the passage of a fireball. See also **Meteor.**

Firecracker flower is a perennial plant of the amaryllis family. It grows in California, U.S.A. Its low, narrow leaves look like blades of grass. The slender stalk may grow to almost 1 metre. The tube-shaped flowers are scarlet, tipped with green. They grow in a cluster at the top of the stalk. The plant grows best in partial shade in deep, loose, well-drained soil with some leaf mould.

Scientific classification. The firecracker flower belongs to the amaryllis family, Amaryllidaceae. It is *Dichelostemma idamaia.*

The firecracker flower has narrow leaves and a long, thin stalk topped by a cluster of red and green tubelike blossoms.

Firedamp. See **Damp.**

Firefly is any member of one particular family of soft-bodied beetles known for producing glowing or flashing light. There are about 1,900 *species* (kinds) of fireflies. Members of the firefly family live on all the continents except Antarctica. Many species of fireflies are active in the early evening, when they can be seen floating silently over meadows and lawns, flashing their yellow lights.

Not all members of the firefly family give off light as adults. However, the *larvae* (young) of all firefly species and the eggs of some species give off light. The glowing larvae and the flightless females of some species are often called *glowworms.* Glowworms glow with a continuous light or light up for long periods.

Adult fireflies are flattish, oblong insects about 5 to 20 millimetres long. Most are dull brown or black, with red, orange, or yellow markings. Like all beetles, fireflies have two pairs of wings but use only the second pair for flying. The first pair of wings, the *elytra,* form a cover over the second pair. The females of many firefly species do not fly, and their wings and elytra are very short or absent.

Firefly light organs are usually located on the underside of the *abdomen*—the last section of an insect's body. A chemical reaction that takes place in the light organs produces the firefly's light. This kind of heatless light is known as *bioluminescence.*

Fireflies have a flat, oblong body, and most have light organs on the underside of the abdomen. The species shown here are *Photinus pyralis, above,* and *Pyractomena ecostata, right.*

Fireflies use their lights to find mates. Each firefly species has its own light signal. Female fireflies on the ground wait until a male flies nearby flashing the correct signal. She then answers him with her own light signal. The females of some firefly species prey on the males of other species. They lure the males by imitating the mating signals of the other species.

Fireflies lay their eggs in moist places on or in the ground. The eggs hatch into flightless larvae that are often seen glowing on damp lawns and along streams. The larvae feed on snails, earthworms, and other insect larvae. They kill their prey by injecting poison into them. They pull the soft body of a snail out of its shell using their hooked *mandibles* (mouthparts). The larvae take one or two years to develop. They then pass through a brief *pupal* state, during which they change into adults. The adults live for between 5 and 30 days. They feed on nectar or eat nothing at all. The enemies of fireflies include various birds, frogs, lizards, and spiders.

Scientific classification. Fireflies are in the class Insecta, order Coleoptera. They make up the firefly family, Lampyridae.

See also **Beetle** (picture); **Bioluminescence.**

Fireman. See **Fire brigade.**

Fireplace. See **Heating** (Local heating systems).

Fireproofing is the popular name for the coatings and methods used to protect paper, plastic, textiles, wood, and other materials against fire. Fire prevention experts, however, consider the term *fireproofing* misleading because even such incombustible materials as steel and concrete are affected to some degree by intense fire. Steel can weaken or melt and concrete can crack. Experts instead refer to materials that have been protected against fire as *fire resistant* or *fire retarded.* They call the substances that are used to protect such materials *fire retardants.*

Fire retardants help prevent materials from burning or being severely damaged when exposed to fire. Some increase the time it takes for treated articles to burst into flame. Others cause a material to extinguish itself if it is ignited by a brief fire, thereby preventing the fire from spreading to surrounding objects.

Fire results from the combination of fuel, heat, and oxygen. Fire retardants help materials resist fire by interfering with *combustion chemistry*—that is, the reactions of these elements with one another. For example, a combustible surface may be protected against fire by being covered with a special fire-retardant *intumescent coating.* Upon exposure to fire, an intumescent coating swells up to form a thick layer of insulating foam between the surface (the fuel) and the fire (the heat).

Many fire retardants produce physical or chemical changes in a flammable material in order to make it less flammable. Some, for example, cause a material, when exposed to fire, to release gases. The gases interfere with combustion chemistry, thereby quenching the flame.

Retardants that alter the flammability of materials are applied in a number of ways. For example, textile manufacturers obtain nearly permanent fire resistance in natural and synthetic fabrics used in making carpets, clothing, draperies, and upholstery through processes that molecularly bond retardant compounds to the fabric. Temporary fire retardation can be obtained by soaking fabrics in solutions of such chemicals as borax, boric acid, diammonium phosphate, and ammonium sulphate. Paper manufacturers often add similar chemicals to paper and cardboard.

In many countries, materials used to build houses, schools, and other buildings are required to meet fire-resistance standards. These standards are set by local governments. Other regulations require that certain types of clothing, such as children's sleepwear, be treated with fire retardants.

Fires of London destroyed large areas of London in 1666 and in 1940.

The Great Fire of London began at Pudding Lane, near Tower Bridge, on Sept. 2, 1666, and ended on Sept. 7, after destroying most of the City of London as far west

The Great Fire of London raged in the City of London for six days in 1666. It destroyed many churches and thousands of homes.

A new London plan, *left,* was designed by Sir Christopher Wren to replace the section of the city destroyed in the Great Fire. But the plan was never used.

as the Temple. London houses in the 1600's were built mainly of wood, and crowded so tightly over the narrow streets that the upper storeys almost touched. There was no effective firefighting system, and a strong wind from the east fanned the flames through houses made abnormally dry by a long, hot summer. Charles II personally supervised demolition operations to make an open strip that the fire could not cross, and, when the wind fell, the danger of the fire spreading farther was over. Samuel Pepys described the Great Fire vividly in his *Diary* (see **Pepys, Samuel**).

The Great Fire destroyed about 13,000 houses in the business area of the city, 89 parish churches, and the old St. Paul's Cathedral. Sir Christopher Wren built the new St. Paul's. The fire had destroyed a dangerous, insanitary area, and new buildings of brick and stone replaced the wooden houses that had been a breeding-ground for disease.

In World War II, during the Blitz on London, extensive areas of the city were destroyed by fire. On Dec. 29, 1940, German aircraft dropped incendiary and high-explosive bombs on central London in an attempt to set fire to the city. They started 1,500 fires, and inflicted severe damage on the London docks. St. Paul's Cathedral barely escaped destruction (see **World War II** [The Battle of Britain]).

Fireweed, also called *willow herb,* is an erect plant that thrives in the North Temperate Zone. It gets its name because it springs up so quickly after a forest fire. It grows to about 1 to 1.8 metres high and looks like a long wand. The narrow leaves are 5 to 15 centimetres long. In the summer, clusters of rose-purple flowers bloom along the upper stalk. The slender fruits are four-sided pods.

Scientific classification. Fireweed belongs to the evening primrose family, Onagraceae. It is *Epilobium angustifolium.*

Firewood. See **Camping** (Building a campfire).

Fireworks are combinations of gunpowder and other ingredients that explode with loud noises and colourful sparks and flames when they burn. Fireworks are also called *pyrotechnics.* Fireworks that only make a loud noise are also called *firecrackers.* Fireworks are dangerous because they contain gunpowder. They should be handled only by experts. Fireworks handled improperly can explode and cause serious injury to the untrained user.

Most fireworks are made by packing gunpowder in hollow paper tubes. A coarse gunpowder tightly packed is used to *propel* (drive) rockets into the air. A finer and more loosely packed gunpowder explodes the rocket once it is in the air. See **Gunpowder.**

Manufacturers add small amounts of special chemicals to the gunpowder to create colours. They add sodium compounds to produce yellow, strontium compounds for red, and copper and barium compounds for blue and green. Charcoal is another substance that can be added to gunpowder. It gives the rocket a sparkling, flaming tail.

How fireworks work. Fireworks rockets, also called *skyrockets,* operate on a principle close to that used in large military rockets. A *fuse* ignites the coarse gunpowder charge, which forms gases that stream out of the end of the paper tube. This propels the rocket into the air. When the rocket is near its highest point of flight, the coarse gunpowder ignites the finer charge, and the finer charge explodes. The explosion breaks up the rocket and ignites many small firecrackers in the *nose* (forward section) of the rocket.

Roman candles have gunpowder charges separated by inactive material so they shoot out separate groups of sparks and coloured flames with series of booming noises. *Catherine wheels,* or *pinwheels,* have a gunpowder charge packed in a long, flexible tube. The tube is attached to the outside edge of a cardboard disc that has a hole in its centre. A stick is placed in the hole. As the charge ignites and burns, it makes the disc whirl around the stick, throwing off sparks and flames. *Lances* are thin paper tubes filled with colour-producing fireworks. They are arranged in a pattern on a wooden frame so that when set afire they outline a scene, a portrait, or a flag.

Other uses of fireworks. Fireworks also have serious uses as warning devices and for illumination. A device called a *fusee* burns with a bright red flame and is used as a signal for caution on roads.

People can signal for help by using a *Very* pistol. The pistol shoots a flare into the air that can be seen far away. *Parachute flares* are used to light up aircraft landing areas. A kind of fireworks rocket can be used to shoot lifelines to shipwrecks. *Star shells* are used in wartime to light up battlefields.

See also **Explosive.**

A first aid course teaches the proper emergency treatment for a variety of injuries and illnesses. In this picture, a student uses a *manikin* (model) of the head and upper torso of the human body to show how to check for a pulse.

First aid

First aid is the immediate care given to a victim of an accident, sudden illness, or other medical emergency. Proper first aid can save a victim's life, especially if the victim is bleeding heavily, has stopped breathing, or has been poisoned. First aid also can prevent the development of additional medical problems that might result from an injury or illness.

Emergency treatment should be administered by the person on the scene who has the best knowledge of first aid. The treatment should be continued until professional medical help is available. First aid also involves reassuring a victim, relieving the pain, and moving the victim, if necessary, to a hospital or clinic.

This article describes some basic first-aid techniques for common medical emergencies. Such emergencies can happen at home, at school, in the street, or in the workplace. Many employers send employees on first-aid courses to learn how to give emergency aid. Organizations such as the Red Cross and the St. John Ambulance Brigade can provide information about first aid training.

It is wise for families to keep a first aid kit in the home. The kit should be kept where children cannot find it, because if it is misused, it could harm them. It should be placed in a strong box and kept in a cupboard, out of children's reach.

General rules for first aid

Analyse the situation quickly and decide whether you can help the victim. If you decide to treat the victim, begin at once. But if you are confused or unsure of yourself, do *not* attempt to give treatment. In many cases, the wrong treatment causes more damage than no treatment at all. For professional help in giving first aid, call a hospital, an emergency medical service, the fire brigade, or the police.

The general steps to take in any situation requiring first aid include the following: (1) call a doctor or ambulance for assistance, (2) provide urgent care for life-threatening emergencies, (3) examine the victim for injuries, and (4) treat the victim for shock.

Call for assistance. Send someone else to call for a doctor, an ambulance, or other help while you care for the victim. If you are alone with the victim, you must decide when you can safely leave to call for assistance. Always treat the victim for any life-threatening conditions before leaving to summon aid.

When telephoning for help, be ready to describe the nature of the victim's illness or injury, the first aid measures you have taken, and the exact location of the victim. Also be prepared to write down any instructions a doctor may give you. Repeat the instructions and ask questions to clarify orders you do not understand.

Every home should have a list of emergency telephone numbers posted on or near to the telephone. However, if such numbers are not available, the operator can assist you in contacting the appropriate emergency service.

Provide urgent care. Certain medical emergencies require immediate care to save the victim's life. If the victim is bleeding severely, has been poisoned, or has stopped breathing, treatment must begin at once. A delay of even a few minutes can be fatal in these cases. The treatments for these emergencies are discussed in this article in the sections on *First aid for bleeding, Treatment for poisoning,* and *Restoring breathing.*

Do not move a victim who may have a broken bone, internal injuries, or damage to the neck or spine, unless absolutely necessary to prevent further injury. If the victim is lying down, keep the person in that position. Do not allow the victim to get up and walk about. Never give food or liquid to a person who may need surgery.

If the victim is unconscious, turn the head to one side to help prevent the person from choking on blood, saliva, or vomit. But do *not* move the head of a person who may have a broken neck or a spinal injury. Never pour a liquid into the mouth of an unconscious person.

Make certain that the victim has an open airway. The *airway* consists of the nose, mouth, and upper throat. These passages must remain open in order for the victim to breathe. For information on keeping the airway open, see the section of this article on *Giving artificial respiration.*

Examine the victim for injuries only after treating the person for any life-threatening emergencies. Then treat the individual injuries. The victim may suffer from diabetes, heart trouble, or some other disease that can cause sudden illness. Many people with such medical problems carry a medical tag or card. The tag or card lists instructions for care that should be followed exactly. It is important that any such information found on the victim be shown to the ambulance crew or doctor who provide emergency aid.

Make the victim comfortable, but handle the person as little as possible. If necessary, shade the victim from the sun or cover the victim to prevent chilling. Loosen the person's clothing. But do not pull on the victim's belt, because this pressure could damage an injured spine.

Remain calm and reassure the victim. Explain what has happened and what is being done. Ask any spectators to stand back.

Treat for shock. Shock results from the body's failure to circulate blood properly. Any serious injury or illness can cause a victim to suffer from shock. Shock most often occurs after an injury that causes blood loss, when there is a probability of heart attack, or during overwhelming infection. When a person is in shock, the blood fails to supply enough oxygen and food to the brain and other organs. The most serious form of shock may result in death.

A victim in shock may appear fearful, light-headed, confused, weak, and extremely thirsty. In some cases, the victim may feel nauseous. The skin appears pale and feels cold and damp. The pulse is rapid and breathing is quick and shallow or deep and irregular. It is best to treat a seriously injured person for shock even if these signs are not present. The treatment will help prevent a person from going into shock.

To treat shock, place the victim on his or her back, with the legs raised slightly. If the victim has trouble breathing in this position, place the person in a half-sitting, half-lying position. Warm the victim by placing blankets over and under the body.

First aid for bleeding

Severe *haemorrhage* (bleeding) can cause death within minutes. Bleeding from most small wounds stops by itself in a short time, after the blood begins to *clot* (thicken). But clotting alone cannot stop the flow of blood from large wounds. When treating a bleeding victim, you should attempt to stop the bleeding, protect the victim from further injury, and prevent shock. As with any situation involving first aid, medical assistance should be called for immediately. Emergency treatments for severe bleeding include such techniques as (1) direct pressure on the wound and (2) pressure on arteries carrying blood to the wound.

Direct pressure. The most effective way of controlling heavy bleeding is to press directly on the wound itself. If possible, have the victim lie down and elevate the bleeding part above the rest of the body. Then place a sterile dressing over the wound and press firmly on it with your hand. If you do not have a sterile dressing, use

How to control bleeding These photographs show how to stop bleeding from an arm or leg. The person giving the treatment applies pressure directly to the wound and raises it above the rest of the body. With his other hand, he helps control the bleeding by pressing on the arteries that supply blood to the affected limb. The diagram indicates the pressure points for the arteries of the arms and legs.

a clean handkerchief, towel, or other cloth folded to make a pad. If no cloth is available, press your hand directly on the wound while someone else obtains the necessary material. Apply constant pressure to the wound for about 10 to 15 minutes, or until medical help arrives.

If the victim bleeds through the first dressing, add another on top of it and apply firmer pressure. Do not remove the first dressing. After the haemorrhage has stopped, secure the dressing with a bandage.

Pressure on arteries. Sometimes, direct pressure and elevation fail to stop severe bleeding. If such bleeding is from an arm or leg, you may be able to stop it by applying pressure to the artery that supplies blood to the injured limb. The illustrations in this article on *How to control bleeding* show the points at which pressure should be applied to these arteries. Pressure on arteries should be used in addition to—not instead of—direct pressure and elevation. Do not apply pressure for longer than 15 minutes.

Treatment for poisoning

There are four ways in which a victim may become poisoned. The poison may be swallowed, inhaled, injected, or absorbed through the skin.

If a poison victim is unconscious, having difficulty breathing, or having seizures, call for an ambulance immediately. If necessary, perform artificial respiration. If the victim has become poisoned by injection, keep the affected area lower than the level of the heart to slow the spread of the poison.

If a person has been poisoned by taking a drug, keep the person's breathing passage open. Quickly try to identify the drug, and then immediately call a doctor or emergency medical service for help.

Swallowed poisons. A person who has swallowed a poisonous substance may die within minutes if not treated. The first step in treating the victim is to identify the poison. Ask the victim what he or she has swallowed. Do this swiftly, for the victim may lose consciousness or become delirious before reaching hospital. Identification of the poison helps determine the proper procedure for treating the victim. Immediately call a doctor for advice. If the victim has swallowed a commercial product, take the container to the phone when you make the call so that you can provide information about the product. The doctor will tell you what to do. Do not put anything in the victim's mouth unless you are told to do so by the doctor.

The doctor may advise you to make the victim vomit. He or she will suggest how you can do this. Vomiting helps get rid of the poison the victim has swallowed. Afterward, encourage the victim to drink as much water as possible. Keep the victim moving about, because activity promotes vomiting.

When a victim vomits, lay the person on his or her side. This position will help keep the airway open and will prevent the victim from inhaling the poisoned vomit into the lungs. Catch the vomit in a pan so that it can be examined by a doctor at the hospital. Send any bottle or container thought to have contained the poison with the victim to hospital.

Inhaled poisons. If the victim has inhaled a poison, such as carbon monoxide or chlorine gas, move the person to fresh air immediately. Open all windows and doors to ventilate the area. Then call for medical help.

Injected poisons include those transmitted by insect stings or bites and snakebite. For information on the treatment of snakebite, see the section on *Snakebite* in this article.

To treat a spider bite, apply cold compresses to the affected area. Afterward, apply a soothing lotion, such as calamine lotion, to the area.

When a person is bitten by a tick, the tick often adheres to the skin or scalp. Remove the tick at once. Pull the tick out steadily and firmly, not suddenly. Do not use your bare hands. Use a glove, a piece of plastic wrap or paper, or even a leaf. If you have tweezers, grasp the tick's mouthparts as close to the skin as possible. Do not attempt to remove the tick by burning it off, by coating it with petroleum jelly, or by putting oil on it. Clean the bite area with soap and water. Save the tick in a small, sealed container for possible identification. If a rash or flulike symptoms develop within the next several weeks, contact a doctor.

When a bee stings a person, the insect's stinger remains in the wound. The person should scrape the stinger off immediately, taking care not to pinch or squeeze the sting. This action reduces the amount of poison that enters the wound.

A victim may experience a severe allergic reaction to a bite or sting. You should either call a doctor for advice or take the victim to hospital for emergency medical treatment.

Poisons on the skin. Poisons can be absorbed through the skin as a result of contact with poisonous plants or chemical substances, such as insecticides. If a victim's skin has been exposed to a poison, remove all contaminated clothing and flush the skin with water for about 10 minutes. Afterward, wash the affected area with soap and water and then rinse it. Wear protective gloves to avoid exposing yourself to the poison.

Restoring breathing

Begin artificial respiration as soon as possible for any victim whose breathing has stopped. Two or three minutes without breathing can cause permanent brain damage, and six minutes can be fatal. Signs of breath stoppage include the lack of regular chest movements and a blue colour in lips, tongue, or fingernails.

Removing the cause of breathing failure. The steps you take before administering artificial respiration depend on why the victim's breathing has stopped. For example, if the victim's airway is blocked, you must remove the obstruction before beginning artificial respiration.

Electric shock also can cause respiratory failure. In cases of electric shock, free the victim from contact with the current before attempting artificial respiration. Turn off the current if possible. Do not touch the victim with your bare hands or with a wet or metal object until the contact has been broken. If you cannot turn off the current, free the victim from contact by using a dry stick, rope, or cloth. Be sure to stand on a dry surface that will not conduct electricity.

Respiratory failure can also result from breathing air that lacks sufficient oxygen. Such air may be present in gas- or smoke-filled rooms, poorly ventilated mines, and

How to give artificial respiration

Open the airway. Place one hand on the victim's forehead and the other under the chin. Then tilt the victim's head back and lift the lower jaw.

For mouth-to-mouth resuscitation, pinch the victim's nostrils shut. Take a deep breath, place your mouth tightly over the victim's mouth, and blow until the victim's chest rises.

Listen for air being exhaled. Remove your mouth and release the victim's nose to allow the victim to breathe out. Repeat the procedure every five seconds for an adult.

other enclosed places. Breathing also may stop because the victim has inhaled large quantities of carbonmonoxide, a substance that interferes with the blood's ability to carry oxygen. In any of these cases, move the victim into fresh air before beginning artificial respiration.

Giving artificial respiration. The most efficient method of artificial respiration is *mouth-to-mouth resuscitation.* To administer mouth-to-mouth resuscitation, place the victim on his or her back, on a firm surface if possible. Kneel down near the head and, using your fingers or a handkerchief, quickly remove such objects as dentures, food, or vomit from the mouth. Place one of your hands under the victim's chin and the other on the forehead. Tilt the victim's head back by lifting with the hand under the chin and pressing down with the one on the forehead. This position—with the chin pointing upward and the neck arched—opens the airway.

To treat an infant or small child, take a breath and place your mouth over both the mouth and nose. Blow gently into the child's mouth and nose. Then remove your mouth and listen for air to flow back out of the child's lungs. Take a breath and blow again. Repeat this procedure every three seconds.

If the victim is an older child or an adult, pinch the nostrils shut with the hand you have placed on the forehead. Take a deep breath, cover the mouth tightly with your own, and blow hard enough to make the chest rise. Then remove your mouth and listen for the return air flow. Repeat this procedure every five seconds.

If the victim's mouth is too large for you to make a tight seal over it with your own, or if the victim has suffered a severe mouth injury, use mouth-to-nose resuscitation. Maintain the head-tilt position, and use the hand under the victim's chin to hold the mouth tightly shut. Then blow into the victim's nose.

If the victim's chest does not rise when you blow in, check the mouth again to be sure that there is nothing in it. Also, make certain that the head is tilted back far enough and that the lower jaw is pulled upward. If you still cannot make the victim's chest expand, it may mean that an object is blocking the airway. The recommended technique for removing an object from the throat is the *Heimlich manoeuvre.* This technique is described in the *Choking* section of this article. After the object has been forced out of the throat, continue artificial respiration until the victim starts to breathe or until medical help arrives.

Other first-aid procedures

Animal bites or stings. Bites made by nonpoisonous animals can result in serious infections and diseases if left untreated. Wash the area of the bite thoroughly with soap and water. Rinse the wound and cover it with a gauze dressing. Call a doctor. If possible, the animal should be kept under observation by a veterinarian to determine if it has rabies.

Bites by poisonous animals include those of some spiders, insects, and snakes. Such bites require medical attention. For information regarding such treatment, see the sections in this article on *Injected poisons* and *Snakebite.*

Burns and scalds. The first-aid treatment of burns and scalds depends on the severity of the injury. Burns are classified, in order of increasing severity, as first-,

second-, or third-degree (superficial, intermediate, and deep). *First-degree burns* produce a reddening of the top layer of skin. *Second-degree burns* damage deeper skin layers. These burns give the injured skin a red or spotted appearance and cause blisters. *Third-degree burns* destroy tissues in the deepest layer of skin. The injury has a white or charred appearance. Scalds are burns caused by hot liquids or by vapours.

Burns and scalds must be cooled as soon as possible. The quickest way to do this is to pour cold water gently over the injury. Then dress the injured area with sterile bandages. Victims suffering burns on the face or over an area larger than the size of the hand should see a doctor immediately.

A person who receives third-degree burns should not be treated at home. The person should instead be treated by a doctor immediately. Large burns may be wrapped in a clean sheet or towel, or in plastic bags or kitchen wrap. Plastic bags or wrap should never be placed over the face. Clothing stuck to the wound should not be pulled away.

In treating any kind of burn, do not open blisters, and do not smear the injury with petroleum ointment, butter, or any greasy substance. If the victim has suffered burns around the face or has been exposed to smoke, watch for respiratory difficulties. If the victim has trouble breathing, give artificial respiration. Severe burns cause much pain and a loss of body fluids and may send the victim into shock. In such cases, take first-aid measures to prevent or treat shock, and rush the victim to hospital.

Chemical burns should be flushed with large amounts of water. Use a hose, shower, or bucket. Wash the injury for at least 10 minutes. Remove any clothing that has been covered by the chemical and cover the burn with a sterile dressing. Take the victim to a doctor immediately.

Sunburn, in most cases, is a superficial burn. Extremely deep sunburn may cause more severe burns, with blistering. Do not open any blisters Apply cool compresses to relieve pain. Consult a doctor in cases of severe sunburn

Choking occurs when food or some other object blocks the *trachea* (windpipe). A person who is choking cannot breathe or speak. After a short time, the victim's skin turns blue and he or she collapses. If the object is not removed in 4 to 6 minutes, death can occur.

An effective way to remove an object blocking the windpipe is a technique called the *Heimlich manoeuvre.* To perform this manoeuvre, stand behind the victim and place your arms around the victim's waist. Make a fist and place it so that the thumb is against the victim's abdomen, slightly above the navel and below the ribcage. Grasp your fist with your other hand and then press your fist into the victim's abdomen with a quick upward thrust. This thrusting action forces air out of the victim's lungs and blows the object from the trachea.

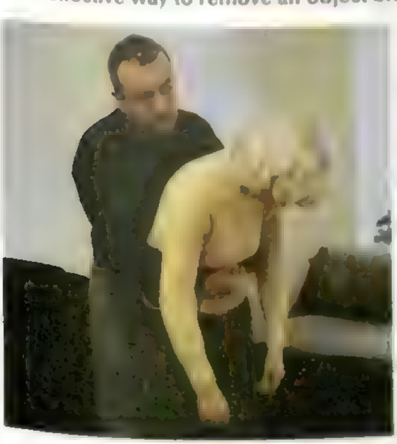
If the victim has collapsed or is too large for you to support or place your arms around, lay the person on his or her back. Then face the victim and kneel straddling the hips. Place one of your hands over the other, with the heel of the bottom hand on the victim's abdomen, slightly above the navel and below the ribcage. Then press your hands into the victim's abdomen with a quick upward thrust.

When applying the Heimlich manoeuvre, be careful not to apply pressure on the victim's ribs. Such pressure may break the ribs of a child or an adult.

Concussion is a head injury affecting the brain that results from a violent blow or shock. If the injury has knocked the victim unconscious, place the victim flat on his or her back, taking care not to move the neck. Give artificial respiration if the breathing stops. Get medical assistance as soon as possible.

Victims of a violent head blow might not lose consciousness at the time of the injury. However, they should be watched closely for the next 12 to 24 hours. They may develop delayed symptoms that should be treated by a doctor. Such delayed symptoms include loss of consciousness, repeated vomiting, severe headache, pale appearance, weakness in the arms or legs, unsteady walking, convulsions, unusual behaviour, difficulty in talking, eye pupils of unequal size, double vision, watery discharge from the ears or nose, and excessive drowsiness. Check the victim for alertness every 15 minutes immediately following the injury and awaken him or her every 3 hours during that night. If signs of a concussion appear, consult a doctor.

Convulsion and epileptic seizure. A person who is suffering a convulsion experiences violent, completely involuntary contractions of the muscles. Major convulsions, particularly those that are associated with epileptic seizures, also involve loss of consciousness. The victim falls to the ground. The muscles twitch and jerk, or they become rigid. Most attacks last a few minutes.



A treatment for choking on an object stuck in the trachea can be applied to a standing victim, *left,* or one who is lying down, *right.* In this technique, called the *Heimlich manoeuvre,* the person giving the treatment presses sharply on the victim's abdomen. The pressure forces air out of the victim's lungs and blows the blockage from the trachea.

Try to prevent the victim from being injured during the attack. Leave the victim in the position in which he or she falls, but move aside objects that the victim might strike during the seizure. Do not attempt to restrain the victim, and do not attempt to move the head. You may, however, loosen the victim's clothing. Put a folded handkerchief between the teeth to prevent the victim from biting the tongue. After the attack, if there is no evidence that the victim may have fallen or may have injured the spine, turn the victim's head to one side to aid breathing, and prevent choking in case vomiting occurs.

Eye injury. If acids or alkalis have been splashed into the eye, immediately flush the eye with water. Flush continuously at least 10 minutes for acids and 20 minutes for alkalis. Use a continuous stream of clean water from a tap or a hose, or pour the water from a cup or other container. Flush the eye from the inside corner outward, to avoid washing the chemical into the other eye. Cover the eye with sterile gauze or a clean pad and take the victim to a doctor.

Dust particles or other foreign objects can be removed from the eye by gently flushing with water. Or they can be removed with the corner of a clean handkerchief. However, do not wipe across the *cornea* (clear central part of the eye) with a handkerchief or any other material. The injured eye must be kept still, to minimize any damage. Warn the victim to keep the uninjured eye still as well, because movement can affect both eyes. Cover the injured eye with a clean dressing. Take the victim to hospital.

Fainting is a brief, sudden period of unconsciousness. It occurs when blood pressure falls to the point where the brain does not receive enough oxygen. In most cases, fainting occurs when a person is standing. The victim falls to the ground while losing consciousness. Leave the victim lying down. Loosen the clothing and raise the feet slightly. Blood will flow back into the head, and the victim should regain consciousness promptly. Should the victim fail to do so, lay the person on his or her side and make certain the airway remains open. Call an ambulance or doctor.

Just before fainting, a person may feel weak or numb. Other symptoms include nausea, light-headedness, blurred vision, pale appearance, sweating, or excessive yawning. A person experiencing these symptoms should lie down or sit with the head between the knees. If the victim has a heart or lung problem, fainting may be a serious condition related to the ailment. Such patients should be seen by a hospital doctor.

Fractures and dislocations. A *fracture* is a break in a bone. A *dislocation* occurs when the end of a bone is forced out of its normal position in a joint. Fractures and dislocations frequently result from traffic and sports accidents.

Signs of fractures and dislocations include pain, an unusual position of a joint or bone, and tenderness and swelling around the injury. The victim may also experience a grating sensation, caused by fragments of broken bone rubbing together. The victim may be unable to use a hand or a foot.

Keep the victim quiet and treat for shock. Whenever possible, do not move the person until expert help arrives. Improper handling of an injured bone or joint may seriously damage arteries, muscles, or nerves. It may also increase the severity of the fracture or dislocation.

A first-aid kit contains a variety of items that can be used to treat minor injuries. These items commonly include adhesive bandages, gauze, antiseptic wipes, and medicated creams.

If you have to move the victim before help arrives, apply a splint to the injured area. The splint prevents broken or dislocated bones from moving. You can make a splint from any material that will support the injured part without bending. For fractures of the arm or leg, the splint should be long enough to prevent movement of joints above and below the injury. Pad the splint surfaces that touch the body. Do not try to correct any deformities before splinting. Do not push bone fragments back into an open wound.

Use strips of cloth to tie the splint above and below the point of injury. Do not tie the splint so tightly that it interferes with circulation. Blueness or swelling in fingers, for example, indicates that a splint has been tied too tightly to an arm.

Do not move a person who may have suffered a broken neck or other spinal injury. A person may receive such an injury by diving into shallow water, falling from a considerable height, or striking the head in a traffic accident. Moving such an accident victim may cause permanent paralysis or death.

Frostbite may occur when the skin is exposed to extreme cold. It most frequently affects the skin of the cheeks, chin, ears, fingers, nose, or toes.

Frostbitten skin appears whitish and feels numb. It should be handled gently. Never massage frostbitten skin, and do not rub it with snow or bathe it in cold water. Warm the affected area with the heat of your hand or cover it with a heavy cloth until you can get the victim indoors. Thaw the affected skin by soaking it in lukewarm water. The temperature of this water should be between 39° and 41° C. Keep the temperature in this range by adding more warm water as needed. Never use water hotter than 41° C. If warm water is not available, wrap the frostbitten area in blankets. Obtain medical assistance as quickly as possible. If a victim of frost-

bite must be moved, protect the person from additional exposure.

Never treat frostbite with heat from a fire or stove, or with a heating pad, hot water bottle, or heat lamp. Such treatment may produce temperatures that can damage frostbitten tissue. If frostbite blisters occur, do not break them. Bandage them to prevent infection.

Heart attack. Most heart attacks begin with a crushing tightness or intense pressure behind the *sternum* (breastbone). This pain may spread across the chest, affecting the arms, the neck, the jaw, or the pit of the stomach. In most cases, it lasts more than five minutes. The victim appears worried, has difficulty breathing, and may perspire heavily and experience feelings of weakness and nausea. He or she may vomit.

Call a doctor or an ambulance. Stay calm and reassure the victim that help is on the way. The victim should not be picked up or allowed to move. Place him or her in the most comfortable sitting or half-sitting, half-lying position. Do not give the victim liquids without a doctor's orders.

In severe heart attacks and serious accidents, the victim's heart may stop beating temporarily. An effective method of treatment in such cases is *cardiopulmonary resuscitation,* or *CPR.* CPR consists of artificial respiration and artificial circulation of the blood. It should be performed only by someone trained in the technique. See **Cardiopulmonary resuscitation.**

Heatstroke and heat exhaustion can occur when the body becomes overheated. Heatstroke is the more serious of the two conditions. A person suffering heatstroke feels hot but cannot sweat. The skin becomes hot, dry, and red. The body temperature rises so high that it can cause brain damage if not lowered quickly. Undress the victim, and apply cold, wet towels to the entire body. Fanning also helps cool the body. Get medical attention as quickly as possible.

A person suffering heat exhaustion, also called *heat prostration,* displays many of the symptoms of shock. Such symptoms include headache, nausea, and feeling faint. The skin is cold, grey, and wet with perspiration. In most cases, the body temperature remains about normal. Treat the victim as if he or she were in shock. Place the victim on his or her back, with the legs raised slightly. If the victim has trouble breathing in this position, place the person in a half-sitting, half-lying position. Take the victim to a hospital, keeping him or her as cool as possible.

Nosebleed. To control a nosebleed, have the victim sit up and lean forward. Then press the nostrils firmly together for 5 to 10 minutes. Consult a doctor if the bleeding does not stop within 10 to 15 minutes.

Snakebite. The treatment of a snakebite depends on whether or not the snake is poisonous. If the snake is nonpoisonous, the bite should be washed thoroughly with soap and water.

A person bitten by a poisonous snake requires medical attention. Most poisonous snakebites cause deep, burning pain along with swelling and discoloration. Within minutes the victim may begin to feel numb and have difficulty breathing. Call a doctor or take the victim to a hospital. If possible, kill the snake and bring it along for identification.

Keep the victim still and quiet, because activity increases the spread of the poison. Place the victim so that the bite is below the level of the heart. If the bite is on an arm or a leg, tie a band above the wound, between it and the heart. The band should be loose enough for you to slip your finger under it. Release the band for 90 seconds every 10 minutes to prevent damage from lack of circulation. For more information on emergency treatment of snakebite, see **Snakebite.**

Transporting the victim

Moving a seriously injured person to a medical facility requires great care. Rough or careless handling can make the victim's injuries even more serious. If a victim must be moved, call an ambulance.

If you have to transport the victim yourself, be sure that you have thoroughly examined the person to determine the full extent of the injuries. All bleeding should be under control, and breathing should be satisfactory and comfortable. Treat the victim for shock and splint any fractures and dislocations. If the victim must be lifted, get someone to help you, in order to avoid rough handling. Whenever possible, use a stretcher to carry a seriously injured person.

If a person may have suffered a back or neck injury, wait for professional help. Move such a victim only if it is necessary to save the person's life. Take great care not to bend or twist the body or neck. Carry the victim on a wide, hard surface, such as a lightweight door.

If you take an injured person to hospital in a car, drive with extra care. If possible, two people should transport the victim. One can ensure that the victim's airway remains open and give comfort, while the other drives.

Related articles in *World Book* include:

Conditions requiring first aid

Asphyxiation
Bee (Sting)
Bleeding
Blister
Bruise
Burns and scalds
Concussion
Dislocation
Drowning
Fainting
Fracture
Frostbite
Haemorrhage
Hypothermia
Nosebleed
Poison
Poison ivy
Rabies
Shock
Snakebite
Stroke
Sunburn
Sunstroke

Other related articles

Ambulance
Antidote
Antiseptic
Bandage
Cardiopulmonary resuscitation
Emetic
Red Cross
Safety
Tourniquet
Ventilator

Outline

I. **General rules for first aid**
   A. Call for assistance
   B. Provide urgent care
   C. Examine the victim
   D. Treat for shock
II. **First aid for bleeding**
   A. Direct pressure
   B. Pressure on arteries
III. **Treatment for poisoning**
   A. Swallowed poisons
   B. Inhaled poisons
   C. Injected poisons
   D. Poisons on the skin
IV. **Restoring breathing**
   A. Removing the cause of breathing failure
   B. Giving artificial respiration
V. **Other first-aid procedures**
   A. Animal bites or stings
   B. Burns and scalds
   C. Choking
   D. Concussion

E. Convulsion and epileptic seizure
F. Eye injury
G. Fainting
H. Fractures and dislocations
I. Frostbite
J. Heart attack
K. Heatstroke and heat exhaustion
L. Nosebleed
M. Snakebite

VI. Transporting the victim

Questions

Why should someone who has swallowed poison be made to vomit, if possible?
Why should an animal that has bitten a person be kept under observation by a vet?
What is the purpose of a splint?
What information should a person administering first aid give a doctor called in an emergency?
Why is it especially important to keep a snakebite victim motionless?
Why should you raise the feet of a person who has fainted?
What are the three types of burns? Which type should always be treated by a doctor immediately?
What techniques should be used to stop severe bleeding in an arm or leg?
What are some of the signs that indicate a person may have suffered a concussion?
What kinds of injuries may cause the condition called *shock*?

First Fleet brought the first convicts from Britain to Australia in 1788. The voyage took eight months.

Preparations. In August 1786, Botany Bay on Australia's east coast was named as the new place to receive convicts transported from Britain. The British Admiralty set about organizing the First Fleet, which was to carry about 700 convicts, together with officials and with marines to guard the prisoners.

The marines and their officers volunteered to go to Botany Bay for three years. They probably did so both because of a sense of "duty to King and country" and in the hope of promotion. Some of the officers were allowed to take their wives and families. Most of the original marines left Australia in 1791, but some stayed on.

The fleet was placed under the command of Captain Arthur Phillip, a naval officer. Phillip was also appointed as the new colony's first governor. Phillip's second-in-command was Captain John Hunter. The colony was to be named *New South Wales.*

The organization of the fleet took some time. The ships had to be specially fitted out to carry the convicts. These ships, called *transports,* had to be altered so that enough fresh air could be provided to the convict quarters belowdecks. The hatches, where guards would stand on duty during the voyage, were securely bolted and fastened. Loopholes for muskets were built into the ships in case the convicts tried to mutiny.

Phillip was not impressed with the quality of much of the food provided for the fleet. He bought more food, particularly food that would prevent *scurvy.* This disease, caused by a lack of vitamin C, was common on ships that had no fresh fruit or vegetables. In order to overcome scurvy, members of the First Fleet grew such green vegetables as beans on board ship on dampened strips of cloth. They also bought such long-lasting fresh vegetables as onions and pumpkins at each port they called at on the way to Australia.

Phillip also bought another ship to relieve overcrowding on the convict ships. Although the first convicts were on board ship as early as January, the fleet did not sail until May 1787. The convicts had to be kept belowdecks in chains and closely guarded during this time.

The fleet. The First Fleet consisted of 11 ships. There were two King's ships, HMS *Sirius* and HMS *Supply.* Both were armed with cannons. Six vessels served as convict transports. The *Alexander* had about 195 male convicts on board. The *Friendship* carried 76 male and 21 female convicts. The *Lady Penrhyn* took 101 female convicts. The *Charlotte* had 89 male and 20 female convicts. The *Scarborough* carried 205 male convicts. The *Prince of Wales* had 2 male and 50 female convicts.

Three store ships completed the fleet. They were the *Barrowdale,* the *Fishburn,* and the *Golden Grove.* The *flag ship,* that is, the ship Phillip sailed on, was the *Sirius.* At 520 metric tons, the *Sirius* was the largest vessel in the fleet. The *Supply,* at 172 metric tons, was the smallest ship in the fleet. The largest of the transports was the *Alexander,* at 459 metric tons, and the largest supply vessel was the *Fishburn,* at 384 metric tons.

By today's standards, the ships that made up the First Fleet were small. For example, the total weight of the fleet was about 4,000 metric tons. The cruise liner *Canberra* is more than 44,000 metric tons—10 times the total weight of the First Fleet. Most of the ships in the fleet were no bigger than the larger ferry-boats that serve Sydney Harbour today.

A party of 1,487 people sailed with the First Fleet. It was made up of 759 convicts, 13 children of convicts, 206 marines with 46 members of their families, 20 officials, 210 seamen of the Royal Navy, and 233 merchant seamen. Six children were born to convict women during the voyage, and four of them survived.

Among the officials aboard the First Fleet were the commander of the marines and Lieutenant Governor Major Robert Ross, Judge Advocate David Collins, Surveyor General August Alt, Chaplain Richard Johnson, and Surgeon General John White. They also included in their number five other medical men and the man in charge of the stores and his assistant.

Enough food was taken on board for part of the voyage. More food was picked up on the way to Botany Bay. The ships arrived with what was thought to be enough food to supply the colony for two years. This food included salted meat. The ships set out from Britain with seed, farm implements, and farm animals to set up farms in the new colony. More seed and farm animals were bought on the voyage at Rio de Janeiro and the Cape of Good Hope. Relying on Sir Joseph Bank's rosy picture of Botany Bay, the First Fleet took not only wheat but also such other crops as cocoa, coffee, grapes, oranges, and bananas. Farm animals taken on the fleet included a bull, cows, sheep, and poultry.

The voyage was marked by rough weather. Many of the convicts and marines became seasick. Men working on deck and in the rigging setting the sails became wet from the seas, and several times, rough seas even wet the convicts belowdecks. The marines were an unruly group, and many of them were punished with the lash during the voyage. They passed their leisure time eating and drinking rum together. Officers passed their spare time reading magazines and books. Some officers visited the other ships in the fleet to dine with their fellow officers and join in a singsong around the piano.

The seamen worked at cleaning the sides and decks of the ship when the weather was calm. When there was no wind at all, the sailing ships could not move, and the men were able to swim in the sea until a fear of sharks forced them to stop. Fish were caught during the voyage, and flying fish and schools of whales were seen.

On a typical day, there was little for the convicts to do except eat their meals and sleep. They were encouraged to read the Bible and religious books, but there is little evidence that they did so with any enthusiasm. They were closely guarded and kept locked belowdecks except during their regular periods of exercise taken on deck. Early on, Phillip ordered that the convicts' chains should be removed so they could move around more easily. This also enabled them to wash. They were also expected to keep their floating prison clean. Water was pumped from the bilges regularly to make conditions belowdecks more bearable.

During fine weather, the hatches were opened to allow air belowdecks. The fresh air and the emphasis on cleanliness probably accounted for the fact that, during the voyage to Botany Bay, only 23 convicts died. This was an extremely low death rate for the time.

Hammocks were provided for sleeping, and tables and stools were provided for eating. Hammocks were used because they took up little space and could be taken down during the day. For this reason, they allowed more convicts to be housed on each ship.

Conditions belowdecks were crowded. In the tropics, it was hot and difficult to breathe. In general, the convicts received more than the rations set by the authorities, and diaries written by people who sailed with Phillip suggest that the prisoners of the First Fleet were well fed by the standards of the time.

Rations were set at two-thirds of the food allowance for ordinary seamen in the Royal Navy. Each week, convicts received salted meat—2 kilograms of beef and 1 kilogram of pork; 1.5 kilograms of oatmeal; 1 kilogram of peas; and butter, cheese, and vinegar. The diet was designed to keep the convicts in relatively good health and to lower their chances of getting scurvy.

More food was bought in the ports of call and distributed to the convicts, particularly rice, fresh meat, and fresh vegetables. Bananas and other tropical fruit were also bought. Women and children received more food when they needed it.

The water ration was set at 3.4 litres a day for each convict. More water was taken on board at the ports of call on the way to Botany Bay. Some water was also collected from rainfall at sea. Only once did Phillip cut the water ration. After he was unable to call at the Cape Verde Islands for fresh water, he cut rations until the fleet docked at Rio de Janeiro.

There was relatively little trouble during the voyage. Phillip commanded the ships extremely well and showed a superb ability in managing not only the convicts but also the civilians. There was some friendly contact between the women convicts and some of the marines, which Phillip stopped by keeping the women convicts belowdecks when the fleet was in port. The convicts fought among each other at times. Those who broke the rules were punished with the lash if their offences were serious. But the use of the lash was rare. In late May, a planned convict mutiny on the *Scarborough* was easily put down, and the two main leaders were flogged. One convict made an unsuccessful attempt to escape at Tenerife. Women convicts who fought among themselves on the *Friendship* were chained belowdecks for 10 days.

The route. The voyage of the First Fleet fell into four stages. The first stage took the fleet from Britain to the Canary Islands, off the northwestern coast of Africa. Next, the fleet sailed from the Canary Islands to the Cape Verde Islands, off the west coast of Africa. The ships then sailed on to Rio de Janeiro, in Brazil. Next they went from Brazil to the Cape of Good Hope (in what is now South Africa). Finally, they sailed from the Cape of Good Hope to Botany Bay, in New South Wales.

The First Fleet, consisting of 11 ships, sailed from England on May 13, 1787. The fleet, commanded by Arthur Phillip, stopped at the Canary Islands, at Rio de Janeiro, and at the Cape of Good Hope. On Jan. 18, 1788, the first ship anchored in Botany Bay.

The route was chosen for several reasons. It allowed the fleet to pick up fresh water. It also allowed Phillip to buy additional supplies, both for the voyage and for establishing a settlement in Botany Bay. The route also took advantage of the wind systems, particularly the westerlies in the southern latitudes, which carried the fleet across the Indian Ocean to Australia. Later fleets used shorter routes, as knowledge of the geography of the route between Australia and Britain grew.

The fleet left the Spithead, in England, on May 13, 1787. By May 20, it had cleared the English Channel. On June 3, the fleet arrived at Tenerife, in the Canary Islands, where it stayed for a week. It then continued on toward the Cape Verde Islands. But bad weather forced Phillip to continue on to Rio de Janeiro, which he reached on August 4. The fleet rested there for a month, taking on supplies before leaving for the Cape of Good Hope. It arrived at the Cape on October 13 and rested there for another month, again taking on supplies.

Phillip's reception by the governor of the Dutch colony was not as warm as the reception he had received from the Portuguese governor of Brazil. But he was able to buy the supplies he needed. The fleet left Table Bay for the last leg of its journey on November 13. Up to this time, the fleet had always sailed as a convoy, the ships never losing sight of each other. But on November 25, Phillip transferred to the *Supply* and, with the *Alexander, Scarborough,* and *Friendship,* pushed on ahead as an advance party. The command of the remaining seven vessels was handed over to Captain Hunter.

Phillip and his advance party sighted the coast of Van Diemen's Land (now Tasmania) on Jan. 5, 1788. Sailing around the south of the island, the ships struck north along the east coast of Australia.

Botany Bay. Phillip and the advance party arrived at Botany Bay on Jan. 18, 1788. The rest of the fleet arrived two days later. The voyage had taken a total of 252 days: 184 days at sea and 68 days in the ports of call.

But Botany Bay was soon found to be unsuitable for settlement—despite the good reports made by Sir Joseph Banks that had influenced the selection of the site as the new penal colony. Fresh water was in short supply in the bay. The bay itself was unprotected against winds—creating a hazard for shipping. The quality of the soil, vital for the growth of the first crops, was poor.

Phillip immediately set out north to locate a new site. He found the entrance to Port Jackson and, at its head, Sydney Cove, with a fresh running stream and a natural harbour, well protected from the winds.

Phillip began to move the members of the fleet to the new site, and the job was completed by January 26. A flagstaff was erected, the King's health drunk, volleys fired from muskets, and the east coast of Australia claimed for the British Crown. Australians now celebrate January 26 as their national day. On January 27, the convicts and the majority of the marines landed. The first permanent European settlement in Australia had been established.

Later events. The *Sirius* was wrecked at Norfolk Island in 1790. Its anchor was raised, and in 1907, it was unveiled on a pedestal in Macquarie Place in Sydney. Three of the ships of the First Fleet were taken over by the East India Company to collect tea from China on the way back to England.

Almost all of the crew of the *Friendship* died of scurvy on the voyage home. Not enough men remained to sail the ship, and it had to be sunk off the coast of Indonesia. The surviving members of the crew were transferred to another ship.

All the rest of the commercial ships returned home to England and were used for other work for a time. But they all eventually disappeared from the records, and historians do not know what finally happened to them.

Related articles in *World Book* include:

Australia, History of	Convicts	Sirius
Botany Bay	Phillip, Arthur	Sydney

First Riel Rebellion. See **Red River Rebellion.**

Firth is a deep, narrow arm of the sea. The term is used mostly in Scotland, but the word *firth* comes from the language of Iceland. In Scandinavia, the word *fiord* has a similar meaning. But fiords always have high walls, and the walls of firths may be low. Both features were probably formed by glaciers. See also **Fiord.**

Firth of Clyde is the broad, irregularly shaped mouth of the River Clyde in southwestern Scotland. The firth is a large bay 80 kilometres long and more than 48 kilometres wide in places. The North Channel connects it with the Atlantic Ocean and with the Irish Sea. Shipping from Glasgow, which lies inland on the River Clyde, has an outlet to the sea through the firth.

Firth of Forth is the large mouth of the River Forth on the east coast of Scotland. The baylike firth connects with the North Sea. The Firth of Forth is 80 kilometres long and 48 kilometres wide at its widest point.

One of the world's longest suspension bridges spans the firth at Queensferry. The bridge was completed in 1964. It is 2,513 metres long and has a 1,006-metre centre span. A cantilever railway bridge 1.6 kilometres long also crosses the firth at Queensferry.

See also **United Kingdom** (physical map).

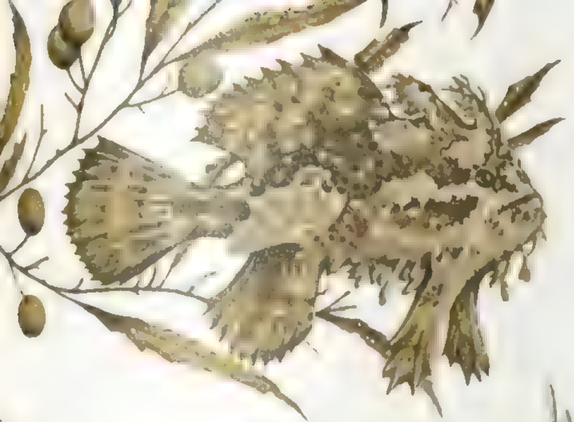
Fischer, Emil (1852-1919), a German chemist, won the 1902 Nobel Prize for chemistry for his wide research. He discovered a method of identifying sugars, and did basic research on proteins, enzyme actions, and purine derivatives such as uric acid and caffeine. He also won fame for his work on dyes. During World War I (1914-1918), he conducted research on carbon, rubber, oils, fats, and other materials. Fischer was born in northern Germany. He taught at the University of Berlin from 1892 until his death.

Fischer, Ernst. See **Nobel Prizes** (table: Nobel Prizes for chemistry—1973).

Fischer-Dieskau, Dietrich (1925-), a German baritone, is one of the finest singers of *lieder* (German art songs) of his time (see **Lieder**). Fischer-Dieskau won international fame for his concerts, his many recordings, and his performances with the world's leading opera companies.

Fischer-Dieskau was born in Berlin and studied music there. He made his debut in 1947 in Brahms's *A German Requiem.*

Dietrich Fischer-Dieskau



A wrasse and a blenny that look alike behave very differently. The wrasse, *bottom,* helpfully removes parasites from the skin of larger fish. The blenny, *top,* attracts larger fish with its wrasselike appearance, then takes a bite out of them.

The sargassum fish, *above,* looks like the seaweed in which it lives. It is almost impossible to see as it climbs among the weeds with its pawlike fins.

The beautiful lionfish has fins that look like a bird's feathers. But they are as sharp as needles and give off a powerful poison. A lionfish often uses its fins to attack other fish. It may even attack skin divers who swim too close to it.

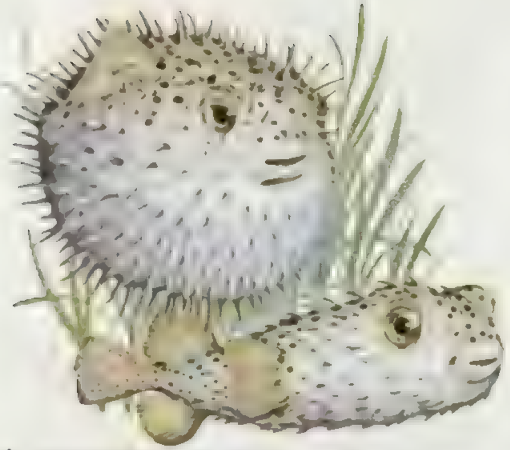
Fish

Fish are *vertebrates* (backboned animals) that live in water. There are more kinds of fish than all other kinds of water and land vertebrates put together. The various kinds of fish differ so greatly in shape, colour, and size that it is hard to believe they all belong to the same group of animals. For example, some fish look like lumpy rocks, and others like wriggly worms. Some fish are nearly as flat as pancakes, and others can blow themselves up like balloons. Fish have all the colours of the rainbow. Many have colours that are as bright as those of the most brightly coloured birds. Their rich reds, yellows, blues, and purples form hundreds of beautiful patterns, from stripes and lacelike designs to polka dots.

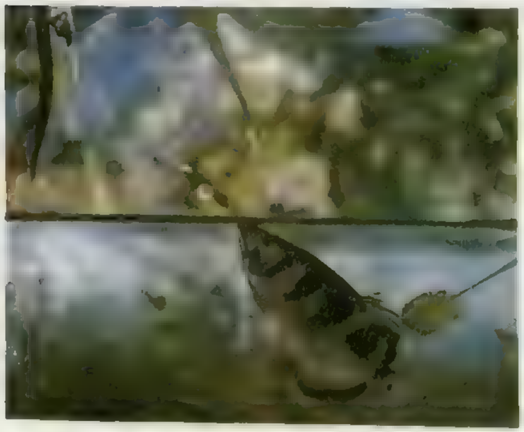
The smallest fish is the *Trimmaton nanus,* a goby of the Indian Ocean, which grows to about 1 centimetre long. The largest fish is the whale shark, which may grow more than 12 metres long and weigh up to 15 metric tons. It is harmless to most other fish and to human beings. The most dangerous fish weigh only a few kilograms. They include the stonefish, whose poisonous spines can kill a human being in a matter of minutes.

Most fish eat shellfish, worms and other water animals. They also eat other fish. Some eat mainly water plants such as algae. Others are *scavengers.* They eat the dead bodies of fish and other animals. The whale shark eats tiny, drifting aquatic organisms called *plankton,* that float in the surface waters of the sea.

Fish live almost anywhere where there is water. They are found in the near-freezing waters of the Arctic and in the steaming waters of tropical jungles. They live in



The porcupinefish is covered with protective spines. For added protection, the fish fills itself with water to change from its normal appearance, *bottom,* to that of a prickly balloon, *top.*



An archerfish catches an insect resting above the surface by spitting drops of water at it. The drops strike with enough force to knock the insect into the water, where the fish can eat it.

Interesting facts about fish

The smallest fish is the *Trimmaton nanus,* a goby of the Indian Ocean. It measures about 1 centimetre when fully grown.

The largest fish is the whale shark. It may weigh about 15 metric tons—over twice as much as an African elephant. This fish is harmless to people. It eats tiny aquatic organisms.

Whale shark

A four-eyed fish, the anableps, has eyes divided in two. When the fish swims just below the surface, the top half of each eye sees above the surface and the bottom half sees underwater.

Anableps

The black swallower can swallow fish twice its own size. Its jaws have "hinges" that enable them to open wide, and its stomach can stretch to several times its normal size. A fish swallowed whole is gradually digested.

Black swallower

The flying hatchet fish is one of the few fish that can really fly. A hatchet fish can take off from the water's surface and fly as far as 3 metres. The fish uses its side fins as wings.

Flying hatchet fish

The walking catfish lives for days out of water and even "walks" on land from one lake to another. The fish has special air-breathing organs and uses its side fins and tail to help it crawl on the ground.

Walking catfish

The largest group of fish are bristlemouths, a kind of tiny saltwater fish. Scientists believe that bristlemouths number in the billions of billions.

roaring mountain streams and in quiet underground rivers. Some fish make long journeys across the sea. Others spend most of their life buried in sand on the bottom of the sea. Most fish never leave water. Yet some fish are able to survive for months in dried-up riverbeds.

Fish have enormous importance to human beings. They provide food for millions of people. Fishing enthusiasts catch them for sport, and people keep them as pets. In addition, fish are important in the *balance of nature.* They eat plants and animals and, in turn, become food for plants and animals. Fish thus help keep in balance the total number of plants and animals on the earth.

All fish have two main features in common. (1) They have a backbone, and so they are vertebrates. (2) They breathe mainly by means of gills. Nearly all fish are also *cold-blooded* animals—that is, they cannot regulate their body temperature, which changes with the temperature of their surroundings. In addition, almost all fish have fins, which they use for swimming. All other water animals differ from fish in at least one of these ways. Dolphins, porpoises, and whales look like fish and have a backbone and fins, but they are *mammals* (animals that feed their young with the mother's milk). Mammals breathe with lungs rather than gills. They are also *warm-blooded*—their body temperature remains about the same when the air or water temperature changes. Some water animals are called *fish,* but they do not have a backbone and so are not fish. These animals include jellyfish and starfish. Clams, crabs, lobsters, oysters, scallops, and shrimps are called *shellfish.* But they also lack a backbone.

The first fish appeared on the earth about 500 million years ago. They were the first animals to have a backbone. Most scientists believe that these early fish became the ancestors of all other vertebrates.

Fish benefit people in many ways. Fish make up a major part of the diet of people in Japan and Norway. In other countries, people eat fish to add variety to their meals. For thousands of years, people have also enjoyed fishing for sport. Many people keep fish as pets. Fish are also important in the balance of nature.

Food and game fish. Fish rank among the most nourishing of all foods. Fish flesh contains about as much protein as meat does. Each year, millions of tons of cod, herring, tuna, and other sea food fish are caught commercially. Commercial fishing also takes place in inland waters, where such freshwater food fish as perch and trout are caught. The *World Book* article on **Fishing industry** discusses commercial fishing throughout the world, as well as the conservation of fish.

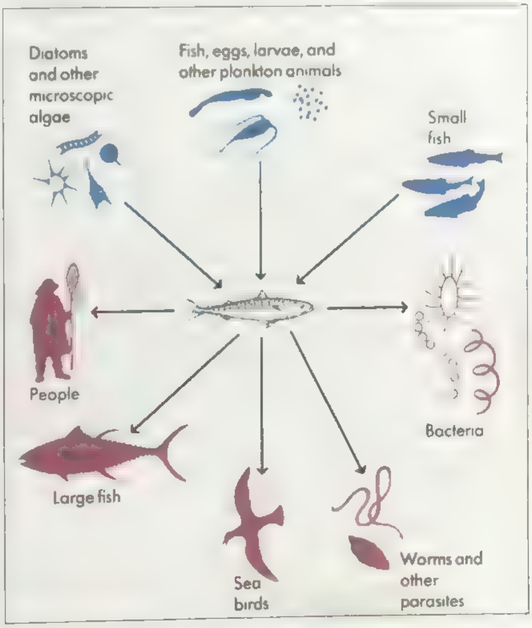
Businesses called *fish farms* raise certain types of fish for food. In some countries, fish farms raise carp, catfish, salmon and trout. Fish farmers raise the fish in ponds and use special feeding methods to make the fish grow larger and faster than they would grow in the wild.

Some people enjoy fishing simply for fun. Many of these people like to go after *game fish.* Game fish are noted for their fighting spirit or some other quality that adds to the excitement of fishing. They include such giant sea fish as marlin and swordfish and such freshwater fish as perch and rainbow trout. Most game fish are also food fish. See the article on **Fishing** for detailed information on sport fishing.

Other useful fish. Some fish are caught commercially but are not good to eat. Such fish are processed to make glue, livestock feed *(fishmeal* and *fish silage),* and other products. Over one-fourth of the world's fish catch is used to make animal feed or oil. In Europe alone, nearly 65 million kilograms of sand eels are used to

Fish in the balance of nature

Fish help keep the number of organisms on the earth in balance. Fish feed on some aquatic organisms and themselves become food for others. This process is called a *food chain.* Fish are part of many food chains, as shown in the diagram below. The blue symbols represent various aquatic organisms that fish eat. The red symbols represent living things that eat fish or are nourished by the matter that remains after fish die and decay.



Fish hatcheries raise fish that are used to stock rivers. The workers at the left are removing the eggs from a female salmon. The eggs are then fertilized with *milt* from a male salmon, *centre.* The fertilized eggs are kept in an *incubator, right,* until they hatch into baby salmon.

make fish products every year. Sprats are also used. In North America, fish products are made from anchovettas and menhaden. Fishmeal is used principally as a feed for pigs and poultry.

Scientists often use goldfish and other small fish as experimental animals in medical research. They do not require as much space or as much care as do other experimental animals. Some fish produce substances used as medicines. For example, a chemical produced by puffers is used to treat asthma. Many people enjoy keeping fish as pets in home aquariums (see **Aquarium**). Popular aquarium fish include goldfish, guppies, and tetras.

Harmful fish. A few species of fish will occasionally attack a human being. They include certain sharks, especially hammerheads and white sharks, barracudas, and moray eels. Certain types of piranhas are bloodthirsty fish with razor-sharp teeth. A group of them can strip the flesh from a human being or other large animal in minutes or even seconds. Some other fish, including sting rays and stonefish, have poisonous spines that can injure or kill anything that comes into contact with them. The flesh of filefish, puffers, and some other fish is poisonous and can cause sickness or death if eaten.

A few species of fish have become pests after being introduced into certain waters. In North America, for example, sea lampreys that entered the Great Lakes and Asian catfish introduced into inland waters of Florida have become a threat to native fish.

Fish in the balance of nature. All the fish in a particular environment, such as a lake or a certain area of the sea, make up a *fish community.* The fish in a community are part of a system in which energy is transferred from one living thing to another in the form of food. Such a system is called a *food chain.* Every food chain begins with the energy from sunlight. Plants use this energy to make their food. In the sea and in fresh water, the most important kinds of plant life are part of the *plankton*—the great mass of tiny plants and animals that drifts near the surface. Certain fish eat plankton and are in turn eaten by other fish. These fish may then be eaten by still other fish. Some of these fish may also be eaten by people or by birds or other animals. Many fish die naturally. Their bodies then sink and decay. The decayed matter provides nourishment for water plants and animals.

Every fish community forms part of a larger natural community made up of all the plants and animals in an area. A natural community includes numerous food chains, which together are called a *food web.* The complicated feeding patterns involved in a food web keep any one form of life from becoming too numerous and so preserve the balance of nature.

The balance of a community may be upset if large numbers of one species in the community are destroyed. People may upset the balance by catching too many fish of a particular kind. Or they may pollute the water so badly that certain kinds of plants and animals, including certain fish, can no longer live in it.

Kinds of fish

Scientists have named and described about 22,000 kinds of fish. Each year, they discover new species, and so the total increases continually. Fish make up more than half of all known species of vertebrates.

The study of fish is called *ichthyology.* Scientists who study fish are *ichthyologists.* They divide fish into two main groups: (1) *jawed* and (2) *jawless.* Almost all fish have jaws. The only jawless species are lampreys and hagfish. Jawed fish are further divided into two groups according to the composition of their skeletons. One group has a skeleton composed of a tough, elastic substance called *cartilage.* Sharks, rays, and chimaeras make up this group. The other group has a skeleton composed largely or partly of bone. Members of this group, called *bony fish,* make up by far the largest group of fish in the world.

The section of this article called *A classification of fish* lists the major subgroups into which bony fish are divided. This section discusses the chief characteristics of (1) bony fish; (2) sharks, rays, and chimaeras; and (3) lampreys and hagfish.

Bony fish

Bony fish can be divided into two main groups according to the composition of their skeletons. One group consists of *modern bony fish,* whose skeletons are composed largely of bone. The second group consists of *primitive bony fish,* whose skeletons are partly bone and partly cartilage.

Modern bony fish consist of about 20,000 species. They make up about 95 per cent of all known kinds of fish. Some have bony skeletons. They are called *teleosts,* which comes from two Greek words meaning *complete* and *bone.* Nearly all food fish, game fish, and aquarium fish are teleosts. They include such well-known groups of fish as bass, catfish, cod, herring, minnows, perch, trout, and tuna. Each group of fish consists of a number of species. For example, coley and pollack are different species of codlike fish.

Thousands of species of teleosts are not so well known. Many live in jungle rivers or coral reefs. Some are deep-sea species seldom seen by human beings. They include more than 150 kinds of deep-sea anglers. These small, fierce-looking fish have fanglike teeth and flashing light organs. They live in the ocean depths and seldom if ever come to the surface. Many teleosts have unusual names and are as strange and colourful as their names. For example, the elephant-nose mormyrid has a snout shaped much like an elephant's trunk. The fish uses its snout to hunt for food along river bottoms. Another strange fish, the upside-down catfish, regularly swims on its back.

Many millions of years ago, there were only a few species of teleosts. They were greatly outnumbered by sharks and the ancestors of certain present-day bony fish. The early teleosts looked much alike and lived in only a few parts of the world. Yet they became the most numerous, varied, and widespread of all fish, mainly

The chief kinds of fish

Bony fish (modern and primitive)

Modern bony fish have a skeleton of bone. They live in both fresh and salt water. Three of the 20,000 species that make up this varied group are shown below.


Skeleton of modern bony fish


Trout

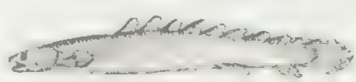

Eel


Flounder

Primitive bony fish have a skeleton consisting of bone and a tough, elastic substance called *cartilage*. These fish live mainly in fresh water. The group includes about 15 species. All are related to fish that died out millions of years ago.


Skeleton of primitive bony fish


Coelacanth


Bichir


Lungfish

Sharks, chimaeras, and rays

The fish in this group have a skeleton of cartilage. They live mainly in salt water. The group includes about 800 species, which differ greatly in size and shape.


Shark skeleton


Shark


Chimaera

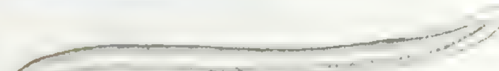

Ray

Lampreys and hagfish

These fish have a cartilage skeleton and no jaws. Lampreys live in salt water and fresh water. Hagfish live only in salt water. There are about 45 species in this group.


Lamprey skeleton


Lamprey


Hagfish

A leaping trout, *above,* is a sight familiar to many people. But some species of fish are seldom seen. Many kinds of fish live in such places as jungle rivers or deep parts of the ocean.

because they were better able than other fish to *adapt* (adjust) to changes in their environment. In adapting to these changes, their bodies and body organs changed in various ways. Such changes are called *adaptations.*

Today, the various species of teleosts differ from one another in so many ways that they seem to have little in common. For example, many teleosts have flexible, highly efficient fins, which have helped them become excellent swimmers. Sailfish and tuna can swim long distances at high speed. Many teleosts that live among coral reefs are expert at darting in and out of the coral. But a number of other teleosts swim hardly at all. Some anglerfish spend most of their adult life lying on the ocean floor. Certain eellike teleosts are finless and so are poor swimmers. They burrow into mud on the bottom and remain there much of the time. Many teleosts have fins that are adapted to uses other than swimming. For example, flying fish have winglike fins that help them glide above the surface of the water. The mudskipper has muscular fins that it uses to hop about on land.

Other modern bony fish include sturgeons, paddlefish, surgeonfish and triggerfish. Sturgeons rank as the largest of all freshwater fish. The largest sturgeon ever caught weighed almost 1,500 kilograms. Instead of scales, sturgeons have an armourlike covering consisting of five rows of thick, bony plates. Some sturgeons live in salt water but return to fresh water to lay their eggs. Paddlefish are strange-looking fish found only in China and the Mississippi Valley of the United States. They have huge snouts shaped somewhat like canoe paddles. Surgeonfish and triggerfish live in the warm, shallow waters of coral reefs. They are usually brightly coloured, and some have beautiful patterns.

Primitive bony fish include about 15 species of bichirs, coelacanths, and lungfish. They make up less than 1 per cent of all fish species. These odd-looking fish are related to fish that lived many millions of years ago.

All the primitive bony fish except the coelacanths live in fresh water. Coelacanths live off the southeast coast of Africa. They are not closely related to any other living fish, and there is only one known species of coelacanth.

Bichirs live in tropical Africa. They are slow-moving fish with a long, thin body and thick scales. Lungfish live in Africa, Australia, and South America. They breathe with lunglike organs as well as gills. The African and South American species can go without food and water longer than any other vertebrates. They live buried in dry mud for months at a time, during which they neither eat nor drink.

Sharks, rays, and chimaeras

Sharks, rays, and chimaeras total about 800 species, or about 3 per cent of all known fish. All have jaws and a skeleton of cartilage rather than bone. Almost all live in salt water. Sharks and rays are the most important members of the group and make up about 760 species.

Most sharks have a torpedo-shaped body. The bodies of most rays are shaped somewhat like a pancake. A large, winglike fin extends outward from each side of a ray's flattened head and body. But the angel shark has a flattened body, and the sawfish and a few other rays are torpedo shaped. As a result, the best way to tell a shark from a ray is by the position of the *gill slits.* In sharks and rays, gill slits are slotlike openings on the outside of the body, leading from the gills. A shark's gill slits are on the sides of its head just behind the eyes. A ray's are underneath its side fins.

Chimaeras, or ratfish, include about 30 species. They are medium-sized fish with large eyes and a long, slender, pointed tail. They live near the sea floor. Several species have long, pointed snouts.

Lampreys and hagfish

Lampreys and hagfish are the most primitive of all fish. There are about 30 species of lampreys and about 15 kinds of hagfish. They make up less than 1 per cent of all fish species. Lampreys live in both salt water and fresh water. Hagfish live only in the sea.

Lampreys and hagfish have slimy, scaleless bodies shaped somewhat like the bodies of eels. But they are not closely related to eels, which are teleosts. Like sharks, rays, and chimaeras, lampreys and hagfish have a skeleton made of cartilage. But unlike all other fish, lampreys and hagfish lack jaws. A lamprey's mouth consists mainly of a round sucking organ and a toothed tongue. Certain types of lampreys use their sucking organ to attach themselves to other fish. They use their toothed tongue to cut into their victim and feed on its blood (see **Lamprey** [picture: The lamprey's mouth]). Hagfish have a slitlike mouth with sharp teeth but no sucking organ. They eat the insides of dead fish.

Where fish live

Fish live almost anywhere where there is water. They thrive in the warm waters of the South Pacific and in the icy waters of the Arctic and Antarctic oceans. Some live high above sea level in mountain streams. Others live far below sea level in the deepest parts of the ocean. Many fish have adapted to living in such unusual places as caves, desert water holes, marshes, and swamps. A few fish, including the African and South American lungfish, can even live for months in moist mud.

Fish thus live in many environments. But all these environments can be classified into two major groups according to the saltiness of the water: (1) saltwater environments and (2) freshwater environments. Some fish can live only in the salty waters. Others can live only in fresh water. Still others can live in either salt water or fresh water. The sections on *The bodies of fish* and *How fish live* discuss how fish adjust to their environment. This section describes some of the main saltwater and freshwater environments. It also discusses fish migrations from one environment to another. A series of colour illustrations shows the kinds of fish that live in the various environments. The illustration for each fish gives the fish's common and scientific names and the average or maximum length of an adult fish.

Saltwater environments. About 13,500 species—or about three-fifths of all known fish—live in the sea. These saltwater, or *marine,* fish live in an almost endless variety of sea environments. Most of them are suited to a particular type of environment and cannot survive in one much different from that type. Water temperature is one of the chief factors in determining where a fish can live. Water temperatures at the surface range from freezing in polar regions to about 30° C in the tropics.

Many saltwater species live where the water is always warm. The warmest parts of the ocean are the shallow tropical waters around coral reefs. More than a third of all known saltwater species live around coral reefs in the Indian and Pacific oceans. Many other species live around reefs in the West Indies. Coral reefs swarm with angelfish, butterfly fish, parrot fish, and thousands of other species with fantastic shapes and brilliant colours. Barracudas, groupers, moray eels, and sharks prowl the clear coral waters in search of prey.

Many other kinds of marine fish live in waters that are neither very warm nor very cold. Such *temperate* waters occur north and south of the tropics. They make excellent fishing grounds. Rich fishing grounds lie off the northwest coast of Europe and the northeast coast of North America. These areas yield huge catches of cod, flatfish, herring, and other food fish. Other important fishing grounds lie around the Falkland Islands. In Australia and New Zealand most of the fishing is done in the shallower waters of the continental shelf. Fish caught there include flathead, snapper, mullet and bream.

The cold waters of the Arctic and Antarctic oceans have fewer kinds of fish than do tropical and temperate waters. Arctic fish include bullheads, eelpouts, skates, and a jellylike, scaleless fish called a sea snail. Fish of the Antarctic Ocean include the small, perchlike Antarctic cod, eelpouts, and the icefish, whose blood is nearly transparent rather than red.

Different kinds of fish also live at different depths in the sea. The largest and fastest-swimming fish live near the surface of the *open sea* and are often found great distances from shore. These fish include bonito, mackerel, marlin, swordfish, tuna, and a variety of sharks. Some of these fish make long annual migrations that range from tropical to near polar waters.

Many more kinds of marine fish live in midwater and in the depths than near the surface. Their environment differs greatly from that of species that live near the surface. Sunlight cannot reach far beneath the surface. Below about 180 metres, the waters range from dimly lit to completely dark. Most fish that live in midwater far out at sea measure less than 15 centimetres long and are black, black-violet, or reddish-brown. Many have light organs that flash on and off in the darkness. Many also have large eyes and mouths.

A number of midwater species are related to the herring. One such group includes the tiny bristlemouths. Scientists believe that bristlemouths outnumber all other kinds of fish. They estimate that bristlemouths number in the billions.

Some fish species live on the sea floor. Many of these fish, such as eels, flounders, puffers, seahorses, and soles, live in shallow coastal waters. But many others live on the bottom far from shore. They include rattails and many other fish with large heads and eyes and long, slender, pointed tails. Many species of rattails grow 30 centimetres or more long. One of the strangest bottom dwellers of the deep ocean is the tripod, or spider, fish. It has three long fins like the legs of a tripod or a three-legged stool. The fish uses its fins to sit on the ocean bottom.

Some kinds of fish live in *brackish* (slightly salty) water. Such water occurs in *estuaries* (where rivers empty into the sea), where salt water collects in coastal swamps, and where pools are left by the outgoing tide. Brackish-water fish include certain species of barracudas, flatfish, gobies, herring, killifish, silversides, and sticklebacks. Some saltwater fish, including various kinds of herring, lampreys, salmon, smelt, and sticklebacks, can also live in fresh water.

Freshwater environments. Fish live on every continent except Antarctica. They are found in most lakes, rivers, and streams and in brooks, creeks, marshes, ponds, springs, and swamps. Some live in streams that pass through caves or flow deep underground.

Scientists have classified about 8,500 kinds of freshwater fish. They make up about two-fifths of all fish species. Almost all freshwater fish are bony fish. Many of these bony fish belong to a large group that includes carp, catfish, characins, electric eels, loaches, minnows, and suckers. In this group, catfish alone total more than 2,000 species.

Tropical regions of Africa, Asia, and South America have the largest number of species of freshwater fish, including hundreds of kinds of catfish. Africa also has many cichlids and mormyrids. A variety of colourful loaches and minnows live in Asia. South American species include electric eels, piranhas, and tetras. Temperate regions of the world also have many freshwater species, including bass, carp, minnows, perch, and trout. Blackfish and pike live in the Arctic.

In every climate, certain kinds of freshwater fish require a particular kind of environment. Some species, including many kinds of graylings, minnows, and trout, live mainly in cool, clear, fast-moving streams. Many species of carp and catfish thrive in warm, muddy, slow-moving rivers. Some fish, such as char, lake trout, and whitefish, live chiefly in lakes. Brown bullheads, large-mouth bass, carp, northern pike, rainbow trout, Nile perch, and many other species are found both in lakes and in streams and rivers.

Like marine fish, freshwater fish live at different levels in the water. For example, many cave, spring, and swamp fish live near the surface. Gars and whitefish ordinarily live in midwater. Bottom dwellers include sturgeon and many kinds of catfish and suckers.

Some freshwater species live in unusual environments. For example, some live in mountain streams so swift and violent that few other forms of life can survive in them. These fish cling to rocks with their mouth or some special suction organ. A number of species live in caves and underground streams. These fish never see daylight. Most of them have pale or white skin, and many of them are blind. A few kinds of freshwater fish live in hot springs where the temperature rises as high as 40° C.

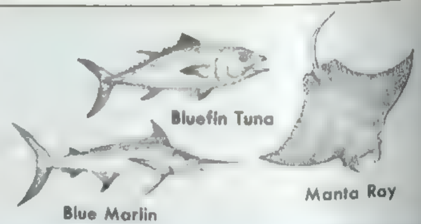
Fish migrations. Relatively few kinds of fish can travel freely between fresh water and salt water. They make such migrations to *spawn* (lay eggs). Saltwater fish that swim to fresh water for spawning are called *anadromous* fish. They include alewives, sea lampreys, smelt, and most species of salmon and shad. Freshwater fish that spawn in salt water are called *catadromous* fish. They include European and North American eels and certain kinds of gobies. Some normally anadromous fish, including large numbers of certain species of alewives, lampreys, salmon, and smelt, have become *landlocked*—that is, rather than returning to their normal saltwater environment, they have become freshwater natives. After hatching, the young do not migrate to the sea. The section *How fish adjust to change* explains why most fish cannot travel freely between salt water and fresh water.

Many saltwater species migrate from one part of the sea to another at certain times of the year. For example, many kinds of mackerel and certain other fish of the open sea move toward shore to spawn. Each summer, many species of haddock and other cold-water fish migrate from coastal waters to cooler waters farther out at sea. Some freshwater fish make similar migrations. For example, some trout swim from lakes into rivers to spawn. Some other fish of temperate lakes and streams, such as bass and perch, live near the warm surface during summer. When winter comes, the waters freeze at the surface but remain slightly warmer beneath the ice. The fish then migrate toward the bottom and remain there until warm weather returns.

Where sea fish live

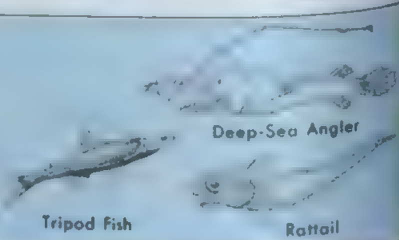
Many kinds of saltwater fish live far from shore. There, the sea can be divided into three main levels according to the amount of sunlight that reaches various depths, *below left.* Different kinds of fish live at each level.

Fish of the upper waters include such fast swimmers as the marlin and tuna. The largest kinds of fish, including the giant manta ray, also live in this region. Many upper-water fish travel great distances and range from tropical to arctic waters. Some often swim close to shore.



Fish of the midwaters include the oarfish, which grows as long as 15 metres. But most midwater fish grow to less than 15 centimetres long. The lantern fish and hatchet fish have light-producing organs, as do most midwater fish. Some kinds of midwater fish swim into the upper waters to feed or lay eggs.

Fish of the depths live in waters that are always cold and almost totally dark. Such waters extend from lower midwaters to the bottom. Lower midwater fish include anglerfish and other species with large mouths and sharp teeth. The rattail and the tripod fish live near the ocean bottom.

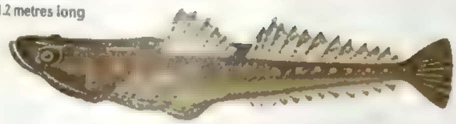


Fish of the southern seas

Many of the fish pictured here, such as the barramundi, black bream, mulloway and nannygai, are caught by commercial fishermen in southern waters. Some fish, such as the barramundi (or calcifer), have a wide distribution and are found as far north as the Red Sea. Only very old specimens of snapper develop a large hump on the forehead. The lagoon ray can cause severe wounds with its poison tail spines.

Mulloway
Sciaena antarctica
1.8 metres long

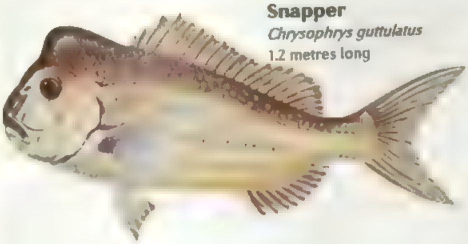
Blue-spotted lagoon ray
Taeniura lymna
2.5 metres long



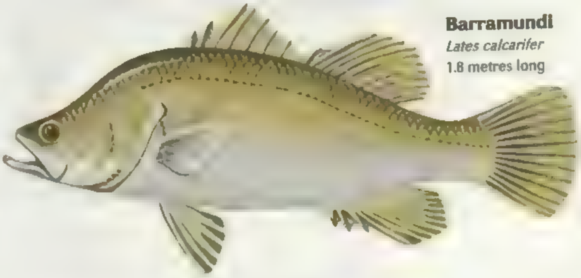
Dusky flathead
Planiprora fusca
1.2 metres long

Stonefish
Synanceja trachynis
40 centimetres long

Yellow leatherjacket
Nelusetta vittata
50 centimetres long



Snapper
Chrysophrys guttulatus
1.2 metres long

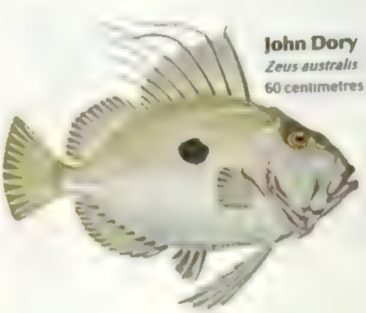


Barramundi
Lates calcarifer
1.8 metres long

Black bream
Acanthopagrus australis
60 centimetres long

Sea mullet
Mugil cephalus
80 centimetres long

Nannygai
Centroberyx affinis
60 centimetres long



John Dory
Zeus australis
60 centimetres long

Moray eel
Verdithorax prasinus
2 metres long

Fish of coastal waters and the open sea

Some saltwater fish live along the coasts of continents. Others live far from shore in the open sea, though many of these fish also swim close to shore from time to time. Both coastal and open-sea species are pictured in these drawings. Fish of the open sea shown here include dolphin fish, flying fish, herring, mackerel, manta ray, marlin, ocean sunfish, sailfish, swordfish, and tuna. Most of the other fish pictured live mainly in coastal waters. Some coastal fish, such as the bull shark and sawfish, always stay close to land. Others, such as the bluefish and great barracuda, sometimes swim far out to sea.

Exciting game fish, such as this striped marlin, live throughout the upper water of the sea. Many saltwater game fish are also important food fish. Fishing fleets catch many far out at sea.

California flying fish
Cypselurus californicus
45 centimetres long

Sailfish
Istiophorus platypterus
3 metres long

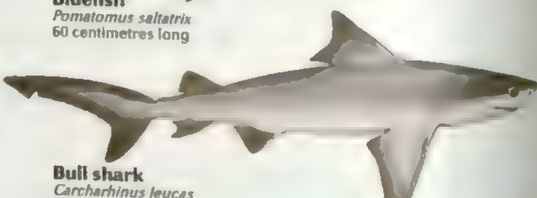
Blue marlin
Makaira nigricans
3 metres long

Atlantic herring
Clupea harengus
30 centimetres long

Swordfish
Xiphias gladius
2 metres long

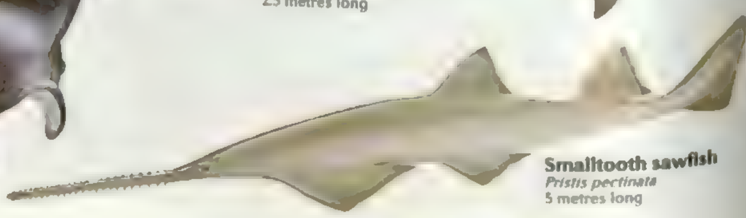
Dolphin fish
Coryphaena hippurus
1.5 to 2 metres long

Bluefish
Pomatomus saltatrix
60 centimetres long



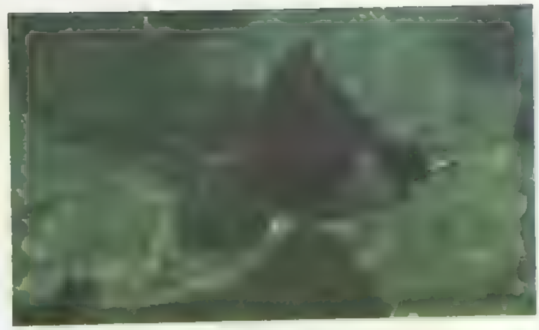
Bull shark
Carcharhinus leucas
2.5 metres long

Atlantic manta ray
Manta birostris
7 metres wide



Smalltooth sawfish
Pristis pectinata
5 metres long

A slow swimmer, the enormous jewfish keeps close to the bottom in coastal waters. Many fish move slowly unless stirred to fast action by an approaching prey or bait.



A spotted eagle ray glides swiftly through coastal waters in search of prey. This dangerous fish has poisonous spines in its tail that can injure or even kill a human swimmer.

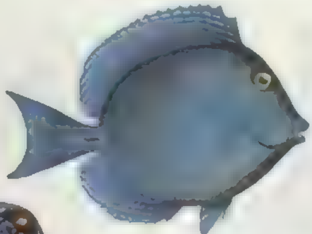
Fish of coral reefs

Hundreds of kinds of saltwater fish live in the warm, shallow waters around coral reefs. Most of these reefs are in the Indian and Pacific oceans and around the West Indies. A reef's clear, sunlit waters swarm with fish that dart in and out of the coral. Many of them are among the most beautiful fish in the world. Reef fish differ greatly in appearance and in many other ways. For example, some are mainly plant eaters, such as parrotfish and surgeonfish. Others, including triggerfish and trunkfish, eat small water animals as well as plants. Still others are *predators* that hunt smaller fish. Such fish include groupers and moray eels.

A fierce hunter, this speckled moray eel lives in and around coral reefs and catches smaller fish as prey. The moray, a snake-like fish with sharp teeth, can attack with lightning speed.

Clown triggerfish
Balistoides conspicillum
40 centimetres long

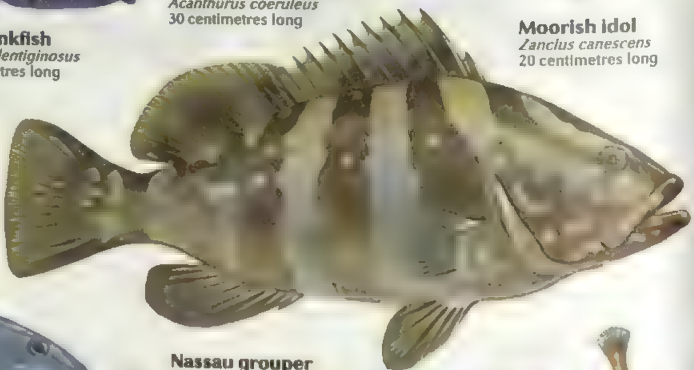
Blue trunkfish
Ostracion lentiginosus
15 centimetres long



Blue tang surgeonfish
Acanthurus coeruleus
30 centimetres long

Moorish idol
Zanclus canescens
20 centimetres long

Picasso triggerfish
Rhinecanthus aculeatus
25 centimetres long



Nassau grouper
Epinephelus striatus
90 to 120 centimetres long

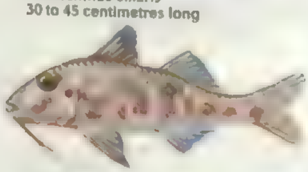
Stoplight parrotfish
Sparisoma viride
60 centimetres long

Neon goby
Gobiosoma oceanops
5 centimetres long

Queen angelfish
Holocanthus ciliaris
30 to 45 centimetres long

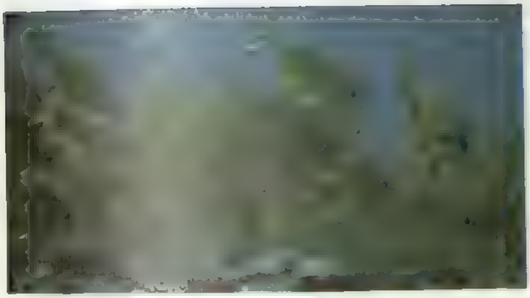
Lined seahorse
Hippocampus erectus
15 centimetres long

Longspine squirrelfish
Holocentrus rufus
20 to 30 centimetres long



Spotted goatfish
Pseudupeneus maculatus
25 centimetres long

Trumpetfish
Aulostomus maculatus
60 centimetres long

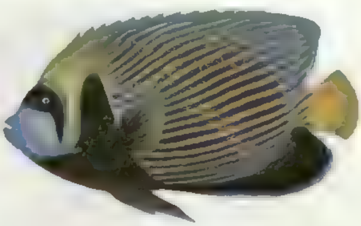


Small, lively swimmers, such as this school of French grunts, create almost constant movement around a reef. Some swim about hunting for food during the day, and others do so at night.

The harlequin tuskfish is one of the many brilliantly coloured species that live among the coral. Dazzling colours or colour patterns may help protect these fish by confusing their enemies.

Clown anemone fish
Amphiprion percula
5 centimetres long

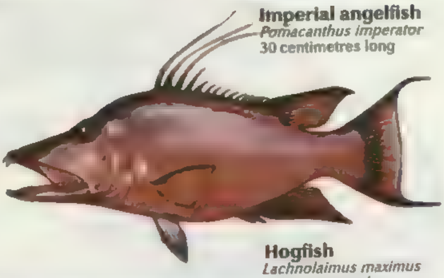
Emperor snapper
Lutjanus sebae
60 centimetres long



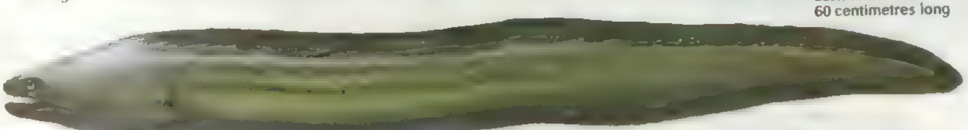
Imperial angelfish
Pomacanthus imperator
30 centimetres long

Long-nosed butterfly fish
Forcipiger longirostris
15 centimetres long

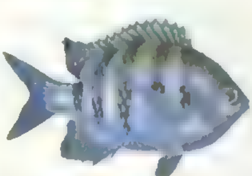
Blue chromis
Chromis cyaneus
15 centimetres long



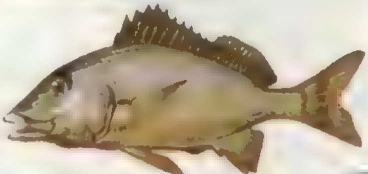
Hogfish
Lachnolaimus maximus
60 centimetres long



Green moray eel
Gymnothorax funebris
2 metres long



Sergeant major damselfish
Abudefduf saxatilis
15 centimetres long



Bluestriped grunt
Haemulon sciurus
30 to 45 centimetres long

Porkfish
Anisotremus virginicus
30 centimetres long

Bluehead
Thalassoma bifasciatum
15 centimetres long

Saddleback butterfly fish
Chaetodon ephippum
15 centimetres long

Flamefish
Apogon maculatus
10 to 15 centimetres long

Scrawled filefish
Aluterus scriptus
90 centimetres long

Fish of the deep ocean

Fish of the deep ocean include some of the most unusual and least-known fish in the world. Many of them have large eyes, huge mouths, fanglike teeth, and light organs that flash on and off in the dark waters of the depths. Most deep-ocean fish seldom, if ever, come to the surface. Oarfish, however, sometimes swim up from the lower midwaters and create the strange appearance of a "sea serpent" as they break the surface. A number of species of deepwater fish are familiar only to scientists and have been given only scientific names. These fish include various brotulids and stomiatoids and certain species of anglers.

A channel rockfish rests on the ocean bottom, 1,200 metres down. There, the water is almost totally dark. This photograph was taken from a submarine with the aid of lights.

Oarfish
Regalecus glesne
5 to 10 metres long

Blue lanternfish
Tarletonbeania crenularis
15 centimetres long

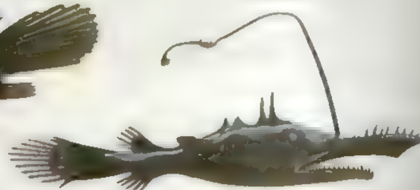
Hatchet fish
Argyropelecus gigas
10 centimetres long

Stomiatoid fish
Bathophilus longipinnis
5 centimetres long

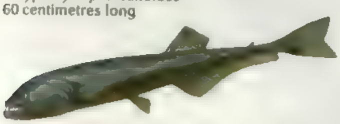
Umbrella mouth gulper eel
Eurypharynx pelecanoides
60 centimetres long

Spiny eel
Notacanthus bonaparti
20 centimetres long

Common blackdevil deep-sea angler
Melanocetus johnsoni
10 centimetres long



Deep-sea angler
Lasiognathus saccostoma
10 centimetres long



Bristlemouth
Gonostoma elongatum
10 centimetres long

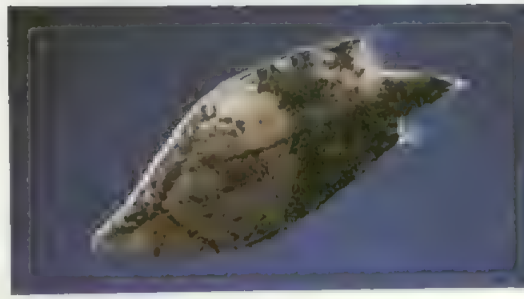
Brotulid fish
Dicrolene nigra
30 centimetres long

California rattail
Nezumia stelgidolepis
30 to 40 centimetres long

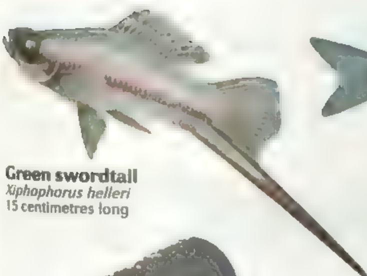
Tripod fish
Bathypterois quadrifilis
25 centimetres long

Fish of tropical fresh waters

Tropical regions of Africa, Asia, and South America have a tremendous variety of freshwater fish. Many of the smaller species are popular aquarium fish. These fish include the guppies, mollies, and swordtails of North and South America, and the Siamese fighting fish of Asia. Large tropical freshwater fish include the giant arapaima, which lives in jungle rivers of South America. The arapaima is one of the largest freshwater fish in the world. Some arapaimas weigh more than 90 kilograms. The elephant-nose mormyrid of tropical Africa uses its long snout to hunt for food under stones and in mud on river bottoms.



The South American leaf fish is one of many unusual species that live in tropical fresh waters. By imitating a floating leaf, this fish escapes its enemies and surprises its prey.



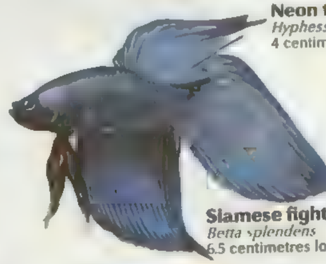
Green swordtail
Xiphophorus helleri
15 centimetres long

Silver hatchet fish
Gasteropelecus levis
6.5 centimetres long

Neon tetra
Hyphessobrycon innesi
4 centimetres long

Mollie
Poecilia latipinna
4 centimetres long

Guppy
Poecilia reticulata
2.5 to 6.5 centimetres long



Siamese fighting fish
Betta splendens
6.5 centimetres long

Arapaima
Arapaima gigas
2.0 to 2.5 metres long

Piranha
Serrasalmus spilopleura
25 centimetres long

Clown loach
Botia macracanthus
30 centimetres long

Knifefish
Gymnotus carapo
60 centimetres long

Elephant-nose mormyrid
Gnathonemus numenius
10 to 15 centimetres long

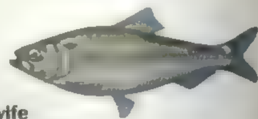
Fish of temperate fresh waters

Unlike tropical waters, temperate waters become cold during part of the year. Fish that live in such waters must adjust their living habits to changes in water temperature. For example, in lakes that freeze over during the winter, most fish move down to warmer water near the bottom and remain there until spring. The fish pictured here live in temperate lakes, rivers, and streams of Europe and North America. Many alewives, salmon, rainbow trout, and white sturgeon live in salt water but swim into fresh water to lay their eggs.

Cavefish live without seeing in the dark waters of caves and underground rivers. These Ozark cave fish have small, sightless eyes, but some other cave fish have no eyes at all.

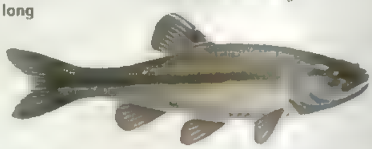
Southern redbelly dace
Phoxinus erythrogaster
8 centimetres long

Common shiner
Notropis cornutus
15 to 20 centimetres long



Alewife
Alosa pseudoharengus
8 to 15 centimetres long

Rainbow darter
Etheostoma caeruleum
8 centimetres long



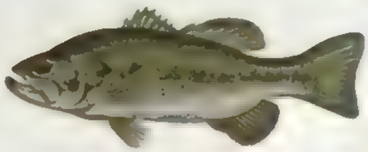
Creek chub
Semotilus atromaculatus
25 to 30 centimetres long

Carp
Cyprinus carpio
30 to 75 centimetres long

Bluegill
Lepomis macrochirus
15 to 23 centimetres long

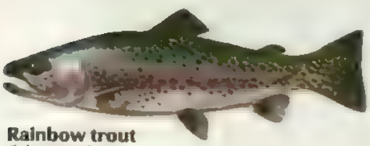
Brook trout
Salvelinus fontinalis
25 centimetres long

Coho salmon
Oncorhynchus kisutch
60 to 90 centimetres long

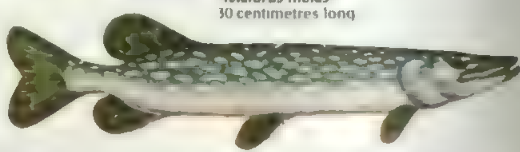


Largemouth bass
Micropterus salmoides
46 centimetres long

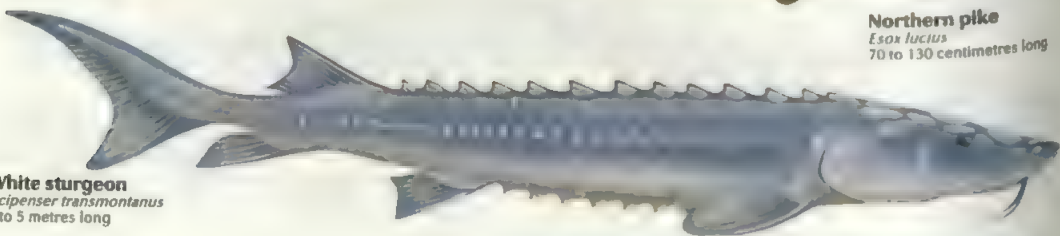
Black bullhead
Ictalurus melas
30 centimetres long



Rainbow trout
Salmo gairdneri
35 centimetres long



Northern pike
Esox lucius
70 to 130 centimetres long



White sturgeon
Acipenser transmontanus
3 to 5 metres long

In some ways, a fish's body resembles that of other vertebrates. For example, fish, like other vertebrates, have an internal skeleton, an outer skin, and such internal organs as a heart, intestines, and a brain. But in a number of ways, a fish's body differs from that of other vertebrates. For example, fish have fins instead of legs, and gills instead of lungs. Lampreys and hagfish differ from all other vertebrates—and from all other fish—in many ways. Their body characteristics are discussed in an earlier section on *Lampreys and hagfish.* This section deals with the physical features that most other fish have in common.

External anatomy

Shape. Most fish have a streamlined body. The head is somewhat rounded at the front. Fish have no neck, and so the head blends smoothly into the trunk. The trunk, in turn, narrows into the tail. Apart from this basic similarity, fish have a variety of shapes. Tuna and many other fast swimmers have a torpedolike shape. Herring, freshwater sunfish, and some other species are flattened from side to side. Many bottom-dwelling fish, including most rays, are flattened from top to bottom. A number of species are shaped like things in their surroundings. For example, anglerfish and stonefish resemble rocks, and pipefish look like long, slender weeds. This camouflage, called *protective resemblance,* helps a fish escape the notice of its enemies and its prey.

Skin and colour. Most fish have a fairly tough skin. It contains blood vessels, nerves, and connective tissue. It also contains certain special cells. Some of these cells produce a slimy *mucus.* This mucus makes fish slippery. Other special cells, called *chromatophores* or *pigment cells,* give fish many of their colours. A chromatophore contains red, yellow, or brownish-black pigments. These colours may combine to produce other colours, such as orange and green. Some species have more chromatophores of a particular colour than other species have or have their chromatophores grouped differently. Such differences cause many variations in colouring among species. Besides chromatophores, many fish also have silvery pigments in their skin and scales. In sunlight, these pigments produce a variety of bright rainbow colours.

The colour of most fish matches that of their surroundings. For example, most fish that live near the surface of the open sea have a blue back, which matches the colour of the water surface. This type of camouflage is called *protective coloration.* But certain brightly coloured fish, including some that have poisonous spines, do not blend with their surroundings. Bright colours may protect a fish by confusing its enemies or by warning them that it has poisonous spines.

Most fish can change their colour to match colour changes that are present in their surroundings. Flatfish and some other fish that have two or more colours can also change the pattern formed by their colours. A fish receives the impulse to make such changes through its eyes. Signals from a fish's nerves then rearrange the pigments in the chromatophores to make them darker or lighter. The darkening or lightening of the chromatophores produces the different colour patterns.

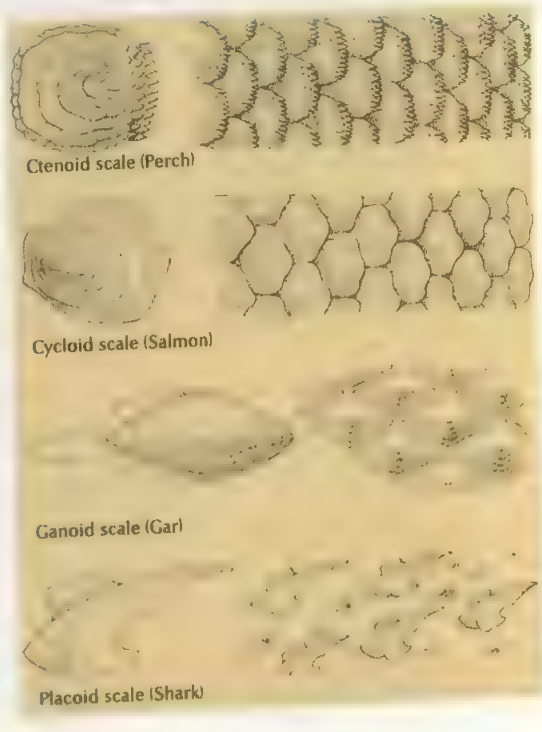
Scales. Most jawed fish have a protective covering of scales. Teleost fish have thin, bony scales that are rounded at the edge. There are two main types of teleost scales—*ctenoid* and *cycloid.* Ctenoid scales have tiny points on their surface. Fish that feel rough to the touch, such as bass and perch, have ctenoid scales. Cycloid scales have a smooth surface. They are found on such fish as carp and salmon. Some primitive bony fish, including bichirs and gars, have thick, heavy *ganoid* scales. Sharks and most rays are covered with *placoid* scales, which resemble tiny, closely spaced teeth. Some fish, including certain kinds of eels and fresh-water catfish, are scaleless.

Fins are movable structures that help a fish swim and keep its balance. A fish moves its fins by means of muscles. Except for a few finless species, all modern bony fish have *rayed fins.* Some primitive bony fish also have rayed fins. These fins consist of a web of skin supported by a skeleton of rods called *rays.* Some ray-finned fish have *soft rays.* Others have both soft rays and *spiny rays,* which are stiff and sharp to the touch. Some primitive bony fish have *lobed fins,* which consist of a fleshy base fringed with rays. Lobed fins are less flexible than rayed fins. Sharks, rays, and chimaeras have fleshy, skin-covered fins supported by numerous fine rays made of a tough material called *keratin.*

Fish fins are classified according to their position on

Kinds of fish scales

These drawings show examples of the four main types of fish scales and the pattern each type forms on the fish's body. Most modern bony fish have ctenoid or cycloid scales. Some catfish and a few other species have no scales at all.



Ctenoid scale (Perch)

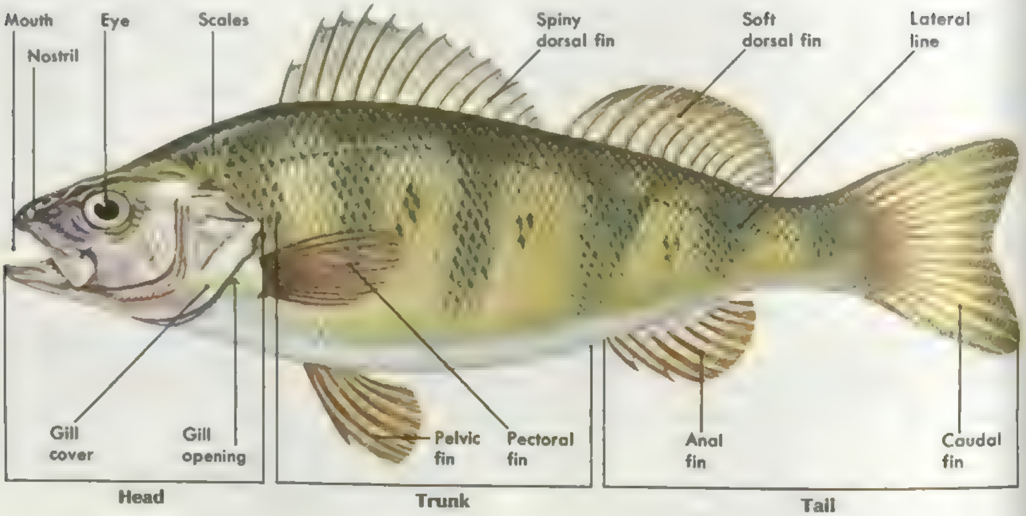
Cycloid scale (Salmon)

Ganoid scale (Gar)

Placoid scale (Shark)

External anatomy of a fish

This drawing of a perch shows the external features most fish have in common. Many kinds of fish do not have all the fins shown here, or they lack such features as gill covers or scales. For example, lampreys and hagfish have no scales and no pelvic or pectoral fins.



the body as well as according to their structure. Classified in this way, a fin is either *median* or *paired.*

Median fins are vertical fins on a fish's back, underside, or tail. They include *dorsal, anal,* and *caudal* fins. The dorsal fin grows along the back and helps a fish keep upright. Almost all fish have at least one dorsal fin, and many have two or three. The anal fin grows on the underside, near the tail. Like a dorsal fin, it helps a fish remain upright. Some fish have two anal fins. The caudal fin is at the end of the tail. A fish swings its caudal fin from side to side to propel itself through the water and to help in steering.

Paired fins are two identical fins, one on each side of the body. Most fish have both *pectoral* and *pelvic* paired fins. The pectoral, or shoulder, fins of most fish grow on the sides, just behind the head. Most fish have their pelvic, or leg, fins just below and behind their pectoral fins. But some have their pelvic fins as far forward as the throat or nearly as far back as the anal fin. Pelvic fins are also called *ventral* fins. Most fish use their paired fins mainly to turn, stop, and make other manoeuvres.

Skeleton and muscles

A fish's skeleton provides a framework for the head, trunk, tail, and fins. The central framework for the trunk and tail is the backbone. It consists of many separate segments of bone or cartilage called *vertebrae.* In bony fish, each vertebra has a spine at the top, and each tail vertebra also has a spine at the bottom. Ribs are attached to the vertebrae. The skull consists chiefly of the brain case and supports for the mouth and gills. The pectoral fins of most fish are attached to the back of the skull by a structure called a *pectoral girdle.* The pelvic fins are supported by a structure called a *pelvic girdle,* which is attached to the pectoral girdle or supported by muscular tissue in the abdomen. The dorsal fins are supported by structures of bone or cartilage, which are rooted in tissue above the backbone. The caudal fin is supported by the tail, and the anal fin by structures of bone or cartilage below the backbone.

Like all vertebrates, fish have three kinds of muscles: (1) *skeletal muscles,* (2) *smooth muscles,* and (3) *heart muscles.* Fish use their skeletal muscles to move their bones and fins. A fish's flesh consists almost entirely of skeletal muscles. They are arranged one behind the other in broad vertical bands called *myomeres.* The myomeres can easily be seen in a skinned fish. Each myomere is controlled by a separate nerve. As a result, a fish can bend the front part of its body in one direction while bending its tail in the opposite direction. Most fish make such movements with their bodies to swim. A fish's smooth muscles and heart muscles work automatically. The smooth muscles are responsible for operating such internal organs as the stomach and intestines. Heart muscles form and operate the heart.

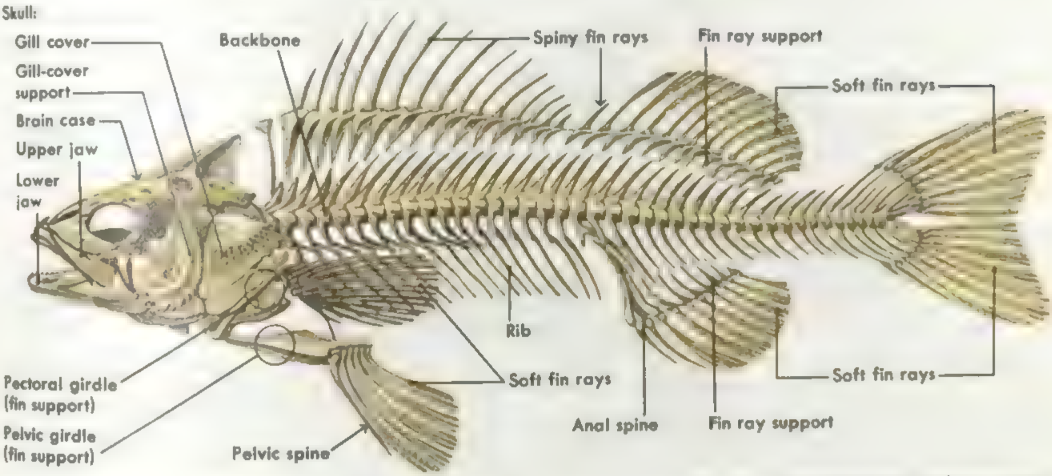
Systems of the body

The internal organs of fish, like those of other vertebrates, are grouped into various systems according to the function they serve. The major systems include the respiratory, digestive, circulatory, nervous, and reproductive systems. Some of these systems resemble those of other vertebrates, but others differ in many ways.

Respiratory system. Unlike land animals, almost all fish get their oxygen from water. Water contains a certain amount of dissolved oxygen. To get oxygen, fish gulp water through the mouth and pump it over the gills. Most fish have four pairs of gills enclosed in a *gill chamber* on each side of the head. Each gill consists of two rows of fleshy *filaments* attached to a *gill arch.*

The skeleton of a fish

The skeletons of most fish consist mainly of (1) a skull, (2) a backbone, (3) ribs, (4) fin rays, and (5) supports for fin rays or fins. The skeleton of a perch is shown below.



Water passes into the gill chambers through *gill slits.* A flap of bone called a *gill cover* protects the gills of bony fish. Sharks and rays do not have gill covers. Their gill slits form visible openings on the outside of the body.

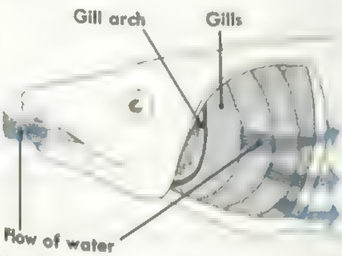
In a bony fish, the breathing process begins when the gill covers close and the mouth opens. At the same time, the walls of the mouth expand outward, drawing water into the mouth. The walls of the mouth then move inward, the mouth closes, and the gill covers open. This action forces the water from the mouth into the gill chambers. In each chamber, the water passes over the gill filaments. They absorb oxygen from the water and replace it with carbon dioxide formed during the breathing process. The water then passes out through the gill openings, and the process is repeated.

Digestive system, or *digestive tract,* changes food into materials that nourish the body cells. It eliminates materials that are not used. In fish, this system leads from the mouth to the *anus,* an opening in front of the anal fin. Most fish have a jawed mouth with a tongue and teeth. A fish cannot move its tongue. Most fish have their teeth rooted in the jaws. They use their teeth to seize prey or to tear off pieces of their victim's flesh. Some of them also have teeth on the roof of the mouth or on the tongue. Most fish also have teeth in the *pharynx,* a short tube behind the mouth. They use these teeth to crush or grind food.

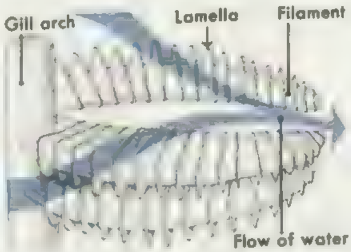
In all fish, food passes through the pharynx on the way to the *oesophagus,* another tubelike organ. A fish's oesophagus expands easily, which allows the fish to swallow its food whole. From the oesophagus, food passes into the *stomach,* where it is partly digested. Some fish have their oesophagus or stomach enlarged into a *gizzard.* The gizzard grinds food into small pieces before it passes into the intestines. The digestive process is completed in the intestines. The digested food enters the blood stream. Waste products and undigested food pass out through the anus.

How a fish's gills work

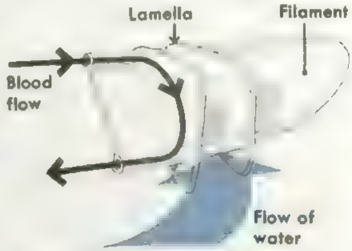
Like all animals, fish need oxygen to change food into body energy. These drawings show how a fish's gills enable it to get oxygen from the water and to get rid of carbon dioxide, a body waste.



Most fish have four gills on each side of the head. Water enters the mouth and flows out through the gills. Each gill is made up of fleshy, threadlike *filaments.*



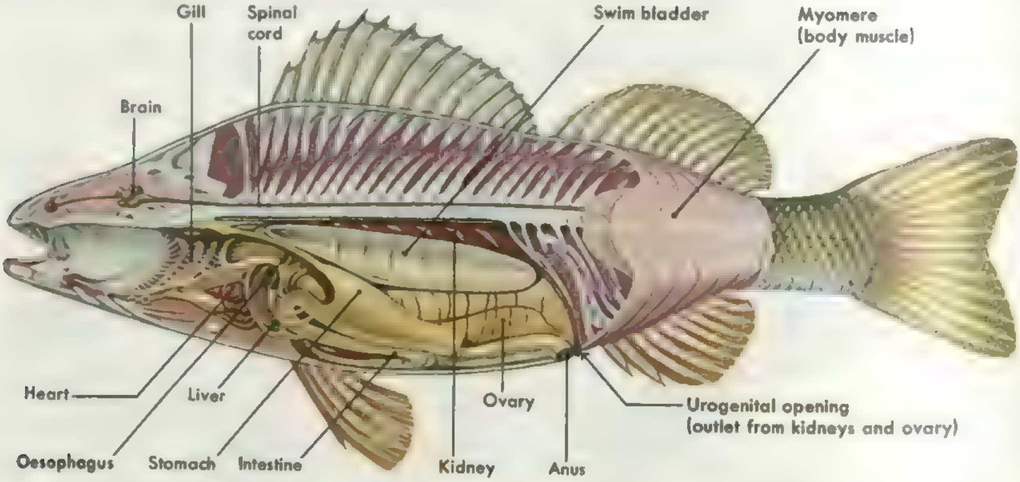
Water from the mouth passes over the filaments, which are closely spaced along a *gill arch* in two rows. Three of the many filaments of a gill are shown above.



Each filament has many tiny extensions called *lamellae.* Blood flowing through a lamella takes oxygen from the water and releases carbon dioxide into the water.

Internal organs of a fish

This view of a perch shows the chief internal organs found in most fish. These organs are parts of the systems that perform such body processes as breathing and digestion.



Circulatory system distributes blood to all parts of the body. It includes the heart and blood vessels. A fish's heart consists of two main chambers—the *atrium* and the *ventricle*. The blood flows through *veins* to the atrium. It then passes to the ventricle. Muscles in the ventricle pump the blood through *arteries* to the gills, where the blood receives oxygen and gives off carbon dioxide. Arteries then carry the blood throughout the body. The blood carries food from the intestines and oxygen from the gills to the body cells. It also carries away waste products from the cells. A fish's kidneys remove the waste products from the blood, which returns to the heart through the veins.

Nervous system of fish, like that of other vertebrates, consists of a *spinal cord, brain,* and *nerves*. However, a fish's nervous system is not so complex as that of mammals and other higher vertebrates. The spinal cord, which consists of soft nerve tissue, runs from the brain through the backbone. The brain is an enlargement of the spinal cord and is enclosed in the skull. The nerves extend from the brain and spinal cord to every part of the body. Some nerves, called *sensory* nerves, carry messages from the sense organs to the spinal cord and brain. Other nerves, called *motor* nerves, carry messages from the brain and spinal cord to the muscles. A fish can consciously control its skeletal muscles. But it has no conscious control over the smooth muscles and heart muscles. These muscles work automatically.

Reproductive system. As in all vertebrates, the reproductive organs of fish are *testes* in males and *ovaries* in females. The testes produce male sex cells, or *sperm*. The sperm is contained in a fluid called *milt*. The ovaries produce female sex cells, or *eggs*. Fish eggs are also called *roe* or *spawn*. Most fish release their sex cells into the water through an opening near the anus. The males of some species have special structures for transferring sperm directly into the females. Male sharks, for example, have such a structure, called a *clasper*, on each pelvic fin. The claspers are used to insert sperm into the female's body.

Special organs

Most bony fish have a swim bladder below the backbone. This baglike organ is also called an air bladder. In most fish, the swim bladder provides *buoyancy*, which enables the fish to remain at a particular depth in the water. In lungfish and a few other fish, the swim bladder serves as an air-breathing lung. Still other fish, including many catfish, use their swim bladders to produce sounds as well as to provide buoyancy. Some species communicate by means of such sounds.

A fish would sink to the bottom if it did not have a way of keeping buoyant. Most fish gain buoyancy by inflating their swim bladder with gases produced by their blood. But water pressure increases with depth. As a fish swims deeper, the increased water pressure makes its swim bladder smaller and so reduces the fish's buoyancy. The amount of gas in the bladder must be increased so that the bladder remains large enough to maintain buoyancy. A fish's nervous system automatically regulates the amount of gas in the bladder so that it is kept properly filled. Sharks and rays do not have a swim bladder. To keep buoyant, these fish must swim constantly. When they rest, they stop swimming and so sink toward the bottom. Many bottom-dwelling bony fish also lack a swim bladder.

Many fish have organs that produce light or electricity. But these organs are simply adaptations of structures found in all or most fish. For example, many deep-sea fish have light-producing organs developed from parts of their skin or digestive tract. Some species use these organs to attract prey or possibly to communicate with others of their species. Various other fish have electricity-producing organs developed from muscles in their eyes, gills, or trunk. Some species use these organs to stun or kill their enemies or prey.

Like all vertebrates, fish have sense organs that tell them what is happening in their environment. The organs enable them to see, hear, smell, taste, and touch. In addition, almost all fish have a special sense organ called the *lateral line system,* which enables them to "touch" objects at a distance. Fish also have various other senses that help them meet the conditions of life underwater.

Sight. A fish's eyes differ from those of land vertebrates in several ways. For example, most fish can see to the right and to the left at the same time. This ability makes up in part for the fact that a fish has no neck and so cannot turn its head. Fish also lack eyelids. In land vertebrates, eyelids help moisten the eyes and shield them from sunlight. A fish's eyes are kept moist by the flow of water over them. They do not need to be shielded from sunlight because sunlight is seldom extremely bright underwater. Some fish have unusual adaptations of the eye. For example, adult flatfish have both eyes on the same side of the head. A flatfish spends most of the time lying on its side on the ocean floor and so needs eyes only on the side that faces upward. The eyes of certain deep-sea fish are on the ends of short structures that stick out from the head. These structures can be raised upward, allowing the fish to see overhead as well as to the sides and front.

A few kinds of fish are born blind. They include certain species of catfish that live in total darkness in the waters of caves and the whalefish, which lives in the ocean depths. Some of these fish have eyes but no vision. Others lack eyes completely.

Hearing. All fish can probably hear sounds produced in the water. Fish can also hear sounds made on shore or above the water if they are loud enough. Catfish and certain other fish have a keen sense of hearing.

Fish have an inner ear enclosed in a chamber on each side of the head. Each ear consists of a group of pouches and tubelike canals. Fish have no outer ears or eardrums to receive sound vibrations. Sound vibrations are carried to the inner ears by the body tissues.

Smell and taste. All fish have a sense of smell. It is highly developed in many species, including catfish, salmon, and sharks. In most fish, the *olfactory organs* (organs of smell) consist of two pouches, one on each side of the snout. The pouches are lined with nerve tissue that is highly sensitive to odours from substances in the water. A nostril at the front of each pouch allows water to enter the pouch and pass over the tissue. The water leaves the pouch through a nostril at the back.

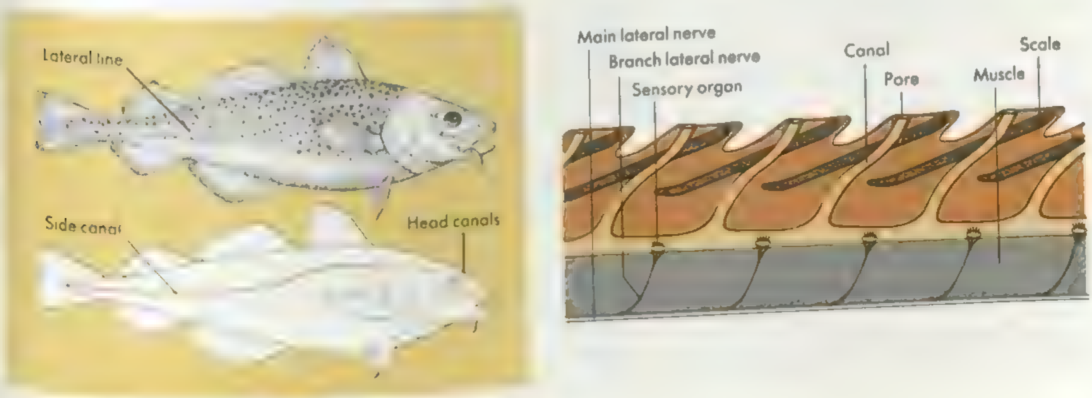
Most fish have taste buds in various parts of the mouth. Some species also have them on other parts of the body. Catfish, sturgeon, and a number of other fish have whiskerlike feelers called *barbels* near the mouth. They use the barbels both to taste and to touch.

Touch and the lateral line system are closely related. Most fish have a well-developed sense of touch. Nerve endings throughout the skin react to the slightest pressure and change of temperature. The lateral line system senses changes in the movement of water. It consists mainly of a series of tiny canals under the skin. A main canal runs along each side of the trunk. Branches of these two canals extend onto the head. A fish senses the flow of water around it as a series of vibrations. The vibrations enter the lateral line through pores and activate certain sensitive areas in the line. If the flow of water around a fish changes, the pattern of vibrations sensed through the lateral line also changes. Nerves relay this information to the brain. Changes in the pattern of vibrations may warn a fish of approaching danger or indicate the location of objects outside its range of vision.

Other senses include those that help a fish keep its balance and avoid unfavourable waters. The inner ears help a fish keep its balance. They contain a fluid and several hard, free-moving *otoliths* (ear stones). Whenever a fish begins to swim in other than an upright, level position, the fluid and otoliths move over sensitive nerve endings in the ears. The nerves signal the brain about the changes in the position of the body. The brain then sends messages to the fin muscles, which move to restore the fish's balance. Fish can also sense any changes in the pressure, salt content, or temperature of the water and so avoid swimming very far into unfavourable waters.

The lateral line system

The lateral line system makes a fish sensitive to vibrations in the water. It consists of a series of tubelike *canals* in a fish's skin. Vibrations enter the canals through *pores* (openings in the skin) and travel to sensory organs in the canals. Nerves connect these organs to the brain.



How fish live

Every fish begins life in an egg. In the egg, the undeveloped fish, called an *embryo,* feeds on the yolk until ready to hatch. The section *How fish reproduce* discusses where and how fish lay their eggs. After a fish hatches, it is called a *larva* or *fry.* The fish reaches adulthood when it begins to produce sperm or eggs. Most small fish, such as guppies and many minnows, become adults within a few months after hatching. But some small fish become adults only a few minutes after hatching. Large fish require several years. Many of these fish pass through one or more *juvenile* stages before becoming adults. Almost all fish continue to grow as long as they live. During its lifetime, a fish may increase several thousand times in size. The longest-lived fish are probably certain sturgeon, some of which have lived in aquariums for more than 50 years. For the life spans of various other fish in captivity, see **Animal** (table: Length of life of animals).

How fish get food. Most fish are *carnivores* (meat-eaters). They eat shellfish, worms, and other kinds of water animals. Above all, they eat other fish. They sometimes eat their own young. Some fish are mainly *herbivores* (plant-eaters). They eat chiefly algae and other water plants. But most plant-eating fish probably also eat animals. Some fish live mainly on plankton. They include many kinds of flying fish and herring and the three largest fish of all—the whale shark, giant manta ray, and basking shark. Some fish are *scavengers.* They feed mainly on waste products and on the dead bodies of animals that sink to the sea floor.

Many fish have body organs specially adapted for capturing food. Certain fish of the ocean depths attract their prey with flashing lures. The dorsal fin of some anglerfish dangles above their mouth and serves as a bait for other fish. Such species as gars and swordfish have long, beaklike jaws, which they use for spearing or slashing their prey. Barracudas and certain piranhas and sharks are well known for their razor-sharp teeth, with which they tear the flesh from their victims. Electric eels and some other fish with electricity-producing organs stun their prey with an electric shock. Many fish have comblike *gill rakers.* These structures strain plankton from the water pumped through the gills.

How fish swim. Most fish gain *thrust* (power for forward movement) by swinging their tail fin from side to side while curving the rest of their body alternately to the left and to the right. Some fish, such as marlin and tuna, depend mainly on tail motion for thrust. Other fish, including many kinds of eels, rely chiefly on the curving motion of their body. Fish manoeuvre by moving their fins. To make a left turn, for example, a fish extends its left pectoral fin. To stop, a fish extends both of its pectoral fins.

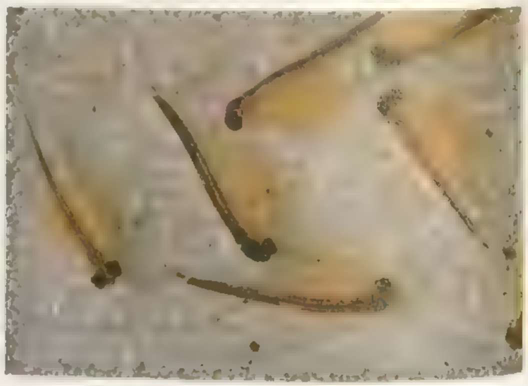
A fish's swimming ability is affected by the shape and location of its fins. Most fast, powerful swimmers, such as swordfish and tuna, have a deeply forked or crescent-shaped tail fin and sickle-shaped pectorals. All their fins are relatively large. At the other extreme, most slow swimmers, such as bowfins and bullheads, have a squared or rounded tail fin and rounded pectorals.

How fish protect themselves. All fish, except the largest ones, live in constant danger of being attacked

How a fish develops

Most fish develop from egg to adult in stages. The photographs below show three stages in the development of trout.

These tiny trout eggs lie among grains of sand. Curled inside each egg is an undeveloped fish called an *embryo.* The large dots are the embryo's eyes. The egg yolk nourishes the embryo.



A newly hatched fish, called a *larva* or *fry,* continues to draw nourishment from the egg yolk by means of blood vessels that extend through the yolk. The yolk is contained in a *yolk sac.*

This 3-month-old trout has used its supply of yolk and now hunts for food. As it grows, it will take on the appearance of an adult trout. Most trout become adults in 2 to 5 years.

A flounder, which has both eyes on one side of its body, lies on the sea floor with both eyes facing up. Flounders change their colour pattern to match the background.

The electric eel stuns its enemies and prey with a powerful electric shock. The electricity-producing organs take up most of the body. The other inner organs lie just behind the head.

and eaten by other fish or other animals. To survive, fish must be able to defend themselves against predators. If a species loses more individuals each generation than it gains, it will in time die out.

Protective coloration and protective resemblance are the most common methods of self-defence. A fish that blends with its surroundings is more likely to escape from its enemies than one whose colour or shape is extremely noticeable. Many fish that do not blend with their surroundings depend on swimming speed or manoeuvring ability to escape from their enemies.

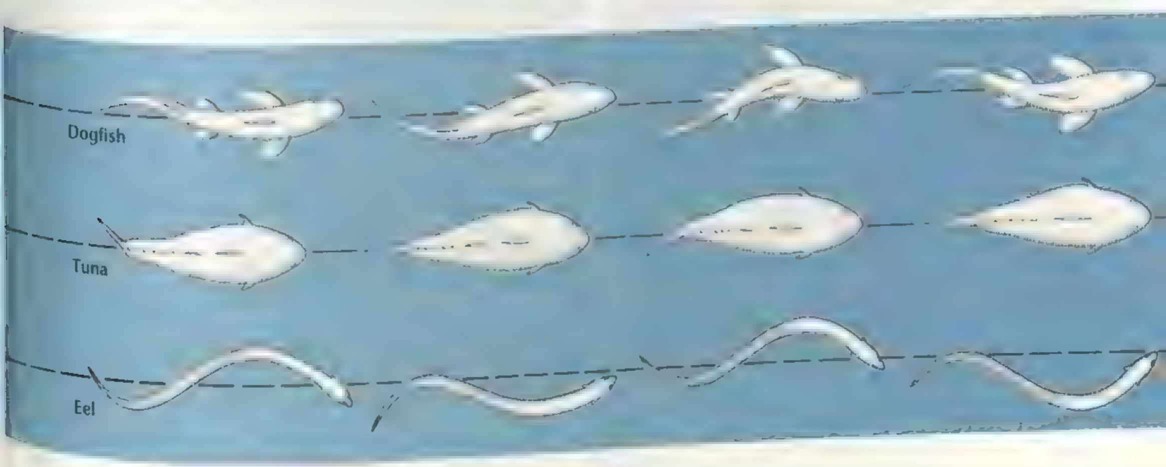
Fish also have other kinds of defence. Some fish, such as gars, pipefish, and seahorses, are protected by a covering of thick, heavy scales or bony plates. Other species have sharp spines that are difficult for predators to swallow. In many species, including scorpionfish, sting rays, and stonefish, one or more of the spines are poisonous. When threatened, the porcupine fish inflates its spine-covered body with air or water until it is shaped like a balloon. The fish's larger size and erect spines may discourage an enemy. Many eels that live on the sea floor dig holes in which they hide from their enemies. Razor fish dive into sand on the bottom. A few fish do the opposite. For example, flying fish and needlefish escape danger by propelling themselves out of the water.

How fish rest. Like all animals, fish need rest. Many species have periods of what might be called sleep. Others simply remain inactive for short periods. But even at rest, many fish continue to move their fins to keep their position in the water.

Fish have no eyelids, and so they cannot close their eyes when sleeping. But while asleep, a fish is probably unaware of the impressions received by its eyes. Some fish sleep on the bottom, resting on their belly or side. Other species sleep in midwater, in a horizontal position. The slippery dick, a coral-reef fish of the Caribbean, sleeps on the bottom under a covering of sand. The striped parrot fish, another coral-reef fish, encloses it-

How fish swim

The dogfish and most other fish swim by swinging their tail from side to side, while curving the rest of their body in the opposite direction. Some fish, such as tuna, move the front of their body little in swimming. Eels and some other fish bend their body in snakelike curves.



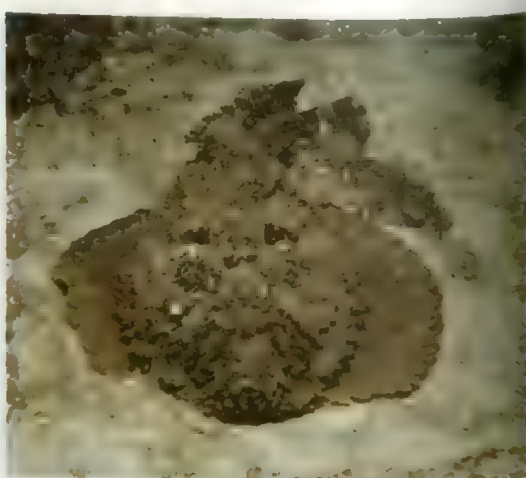

A fleshy bait grows from the head of an anglerfish, *above left,* and out of the mouth of a stargazer, *above right.* The wormlike bait attracts smaller fish. Anglerfish and stargazers snap up small fish with astonishing speed, but they move slowly at most other times.

self in an "envelope" of mucus before going to sleep. The fish secretes the mucus from special glands in its gill chambers.

Certain air-breathing fish, such as the African and South American lungfish, sleep out of water for months at a time. These fish live in rivers or ponds that dry up during periods of drought. The fish lie buried in hardened mud until the return of the rainy season. This kind of long sleep during dry periods is called *aestivation.* During aestivation, a fish breathes little and lives off the protein and fat stored in its body.

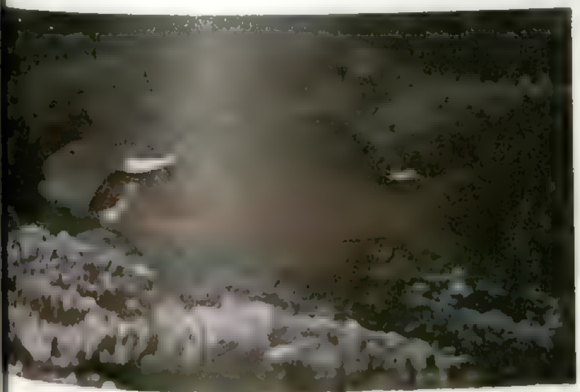
How fish live together. In many species, the individual fish live mainly by themselves. Such fish include most predatory fish. Many sharks, for example, hunt and feed by themselves and join other sharks only for mating.

In many other species, the fish live together in closely knit groups called *schools* or shoals. About a fifth of all fish species are schooling species. A school may have few or many fish. A school of tuna, for example, may consist of fewer than 25 individuals. Many schools of herring number in the hundreds of millions. All the fish in a school are about the same size. Baby fish and adult fish are never in the same school. In some schooling species, the fish become part of a school when they are young and remain with it throughout their lives. Other species form schools for only a few weeks after they hatch. The fish in a school usually travel in close formation as a defence against predators. But a school often breaks up at night to feed and then regroups the next morning. The approach of a predator brings the fish quickly back together.

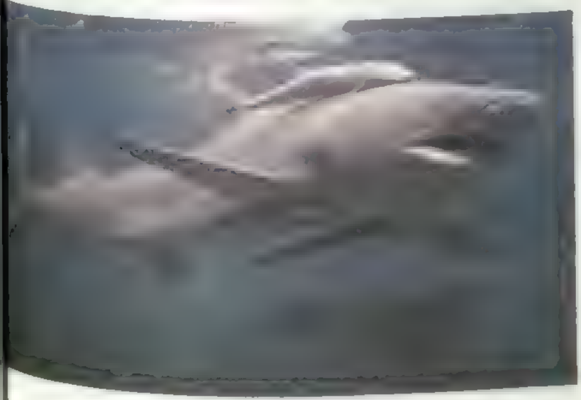



Fish protected by spines include the demon stinger, *above left,* and the stonefish, *above right.* Both fish give off poison through their spines. The stonefish's poison is the deadliest of all fish poisons. It can kill a human being in minutes.

Thousands of sardines make up this school. They live together most of the time but may separate at night to feed. They swim quickly back together when threatened by an enemy.



A coral trout and a wrasse help each other. The small wrasse is removing parasites from the gills of the coral trout. The wrasse thus obtains food and the coral trout is cleaned.



Three remoras ride on a lemon shark. The remoras use a sucking disk on their head to hold on to the shark. They also eat scraps of the shark's food

Fish also form other types of relationships. Among cod, perch, and many other species, a number of individuals may gather in the same area for feeding, resting, or spawning. Such a group is only temporary and is not so closely knit as a school. Some fish, including certain angelfish and wrasses, form unusual relationships with larger fish of other species. In many such relationships, the smaller fish removes parasites or dead tissue from the larger fish. The smaller fish thus obtains food, and the other is cleaned.

How fish adjust to change. Fish sometimes need to adjust to changes in their environment. The two most common changes are (1) changes in water temperature and (2) changes in the salt content of water.

In general, the body temperature of each species of fish equals that of the water in which the species lives. If the water temperature rises or falls, a fish can adjust to the change because its body temperature changes accordingly. But the change in the water temperature must not be too great and must occur gradually. Most fish can adjust to a change in the water temperature of up to about 8° C—if the change is not sudden. Water temperatures usually change slowly, and so there is time for a fish's body to make the necessary adjustment. But occasionally, the temperature drops suddenly and severely, killing many fish. In addition, freshwater fish are sometimes endangered by *thermal pollution,* which occurs when factories and electric power plants release hot water into rivers or lakes. The resulting increase in water temperature may be greater than most fish can adjust to.

Both fresh water and sea water contain various salts, many of which fish need in their diet. But sea water is far saltier than fresh water. Fish that migrate between the two must adjust to changes in the salt content of the water. Relatively few species of fish can make such an adjustment.

Both freshwater and saltwater fish have about the same amount of dissolved salts in their body fluids. But the body fluids of marine fish are not as salty as the water in which the fish live. Under certain circumstances, water from a weak solution will flow into a strong solution. This natural process, called *osmosis,* takes place if the two solutions are separated by a *membrane* (thin layer) through which only the water can pass (see **Osmosis**). The skin and gill membranes of fish are of this type. For this reason, marine fish constantly lose water from their body fluids into the stronger salt solution of the sea water. To make up for this loss, they drink a lot of water. But sea water contains more salt than marine fish need. The fish pass the extra salt out through their gills and through their digestive tract. Saltwater fish need all the water they drink. As a result, these fish produce only small amounts of urine.

Freshwater fish have the opposite problem with osmosis. Their body fluids are saltier than fresh water. As a result, the fish constantly absorb water through their membranes. In fact, freshwater fish absorb so much water that they do not need to drink any. Instead, the fish must get rid of the extra water that their bodies absorb. As a result, freshwater fish produce great quantities of urine.

All fish reproduce sexually. In sexual reproduction, a sperm unites with an egg in a process called *fertilization.* The fertilized egg develops into a new individual. In almost all fish species, males produce sperm and females produce eggs. In a few species, the same individual produces both sperm and eggs.

The eggs of most fish are fertilized outside the female's body. A female releases her eggs into the water at the same time that a male releases his sperm. Some sperm come in contact with some of the eggs, and fertilization takes place. This process is called *external fertilization.* The entire process during which eggs and sperm are released and the eggs are fertilized is called *spawning.* Almost all bony fish reproduce in this way.

Sharks, rays, chimaeras, and a few bony fish, such as guppies and mosquito fish, reproduce in a different manner. The eggs of these fish are fertilized inside the female, a process called *internal fertilization.* For internal fertilization to occur, males and females must mate. The males have special organs for transferring sperm into the females. After fertilization, the females of some species release their eggs into the water before they hatch. Other females hatch the eggs inside their bodies and so give birth to living young. Fish that bear living young include many sharks and rays, guppies, and some halfbeaks and scorpionfish.

This section discusses spawning, the method by which most fish reproduce.

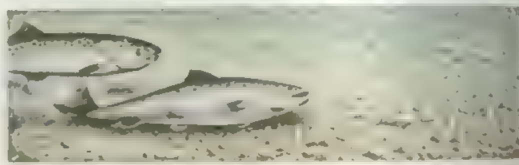
Preparation for spawning. Most fish have a *spawning season* each year, during which they may spawn several times. But some tropical species breed throughout the year. The majority of fish spawn in the spring or early summer, when the water is warm and the days are long. However, certain cold-water fish, such as the brook trout and the Atlantic cod, spawn in the autumn or winter.

Most fish return to particular *spawning grounds* year after year. Many freshwater fish have to travel only a short distance to their spawning grounds. They may simply move from the deeper parts of a river or lake to shallow waters near the shore. But other fish may migrate tremendous distances to spawn. For example, European freshwater eels cross nearly 5000 kilometres of ocean to reach their spawning grounds in the western Atlantic.

At their spawning grounds, the males and females of some species swim off in pairs to spawn. Among other species, the males and females spawn in groups. Many males and females tell each other apart by differences in appearance. The females of some species are larger than the males. Among other species, the males develop unusually bright colours during the spawning season. During the rest of the year, they look much like the females of their species. In some species, the males and females look so different that for many years scientists thought they belonged to different species. Among other fish, the sexes look so much alike that they can be told apart only by differences in their behaviour. For example, many males adopt a special type of *courting* behaviour to attract females. A courting male may swim round and round a female or perform a lively "dance" to attract her attention.

How fish reproduce

Fish reproduce *sexually*—by uniting a *sperm* (male sex cell) with an *egg* (female sex cell). In most species, the union of sex cells takes place in the water. Trout reproduction is shown below.



The female trout, *above centre,* makes a nest for her eggs. She uses her tail to scoop the nest out on the gravelly bottom. The male trout, *left,* does not help make the nest.

After the nest has been made, the male moves alongside the female. As the female releases her eggs, the male releases his sperm. The sperm cells unite with the eggs in the nest.

The female then covers the nest to protect the eggs. She heads into the current and swishes her tail in the gravel to stir it up. The current carries the loosened gravel back over the eggs.

Among some species, including cod, Siamese fighting fish, and certain gobies and sticklebacks, a male claims a territory for spawning and fights off any male intruders. Many fish, especially those that live in fresh water, build nests for their eggs. A male freshwater bass, for example, uses its tail fin to scoop out a nest on the bottom of a lake or stream.

Spawning and care of the eggs. After the preparations have been made, the males and females touch in a certain way or make certain signals with their fins or body. Depending on the species, a female may lay a few eggs or many eggs—even millions—during the spawning season. Most fish eggs measure 3 millimetres in diameter or less.

Some fish, such as cod and herring, abandon their eggs after spawning. A female cod may lay as many as 9 million eggs during a spawning season. Cod eggs, like those of many other marine fish, float near the surface and scatter as soon as they are laid. Predators eat many of the eggs. Other eggs drift into waters too cold for hatching. Only a few cod eggs out of millions develop into adult fish. A female herring lays about 50,000 eggs in a season. But herring eggs, like those of certain other

marine fish, sink to the bottom and have an adhesive covering that helps them stick there. As a result, herring eggs are more likely to successfully hatch.

The bitterling spawns in an unusual way. The female uses a long tube (her *ovipositor*) to deposit eggs in a mussel or other shellfish. The male's sperm is taken up by the shellfish, and fertilization takes place inside it.

A number of fish protect their eggs. They include many freshwater nest builders, such as bass, salmon, certain sticklebacks, and trout. The females of these species lay far fewer eggs than do the females of the cod and herring groups. Like herring eggs, the eggs of many freshwater nest builders sink to the bottom and have an adhesive covering. But they have a better chance of surviving because they get some protection.

The amount and kind of protection vary. Salmon and trout cover their fertilized eggs with gravel but abandon them soon after. The male of the common goby guards the eggs until they hatch. Among marine fish, female seahorses and pipefish lay their eggs in a pouch on the underside of the male. The eggs hatch inside the male's pouch. Some fish, including certain marine catfish and cardinal fish, carry their eggs in their mouth during the hatching period. In some species, the male carries the eggs. In other species, the female carries them.

Hatching and care of the young. The eggs of most fish species hatch in less than two months. Eggs laid in warm water hatch faster than those laid in cold water. The eggs of some tropical fish hatch in less than 24 hours. The eggs of certain cold-water fish require four or five months to hatch. The males of a few species guard their young for a short time after they hatch. These fish include largemouth bass, bowfins, brown bullheads, Siamese fighting fish, and some sticklebacks. But most fish provide no protection for their offspring.

A male Siamese fighting fish blows bubbles that stick together to make a nest for eggs laid by the female. He then collects the eggs in his mouth and blows them into the nest.

A baby lemon shark is born well-developed and attached to the female by an umbilical cord. Some shark species hatch eggs inside their bodies. Others lay their eggs in the water.

Mouthbreeding fish hold their eggs in their mouth before hatching. This male jawfish has a mouthful of eggs. Females of some species and males of others hold the eggs.

The development of fish

A fish that lived 58 million years ago left its "picture" in this fossil Such fossils reveal many details about fish that are now extinct. Scientists study fossils to discover how fish developed through the ages.

Scientists learn how fish developed by studying the fossils of fish that are now extinct. The fossils show the changes that occurred in the anatomy of fish down through the ages.

The first fish appeared on the earth about 500 million years ago. These fish are called *ostracoderms.* They were slow, bottom-dwelling animals that were covered from head to tail with a heavy armour of thick bony plates and scales. Like today's lampreys and hagfish, ostracoderms had no jaws and had poorly formed fins. For this reason, scientists group lampreys, hagfish, and ostracoderms together. Ostracoderms were not only the first fish, they were also the first animals to have a backbone. Most scientists believe that the history of all other vertebrates can be traced back to the ostracoderms. The ostracoderms gave rise to jawed fish with backbones, and they in turn gave rise to *amphibians* (vertebrates that have legs and live both on land and in water). The amphibians became the ancestors of all land vertebrates.

Ostracoderms probably reached the peak of their development about 400 million years ago. About the same time, two other groups of fish were developing—*acanthodians* and *placoderms.* The acanthodians became the first known jawed fish. The placoderms were the largest fish up to that time. Some members of the placoderm group called *Dinichthys* grew up to 9 metres long and had powerful jaws and sharp bony plates that served as teeth.

The Age of Fishes was a period in the earth's history when fish developed remarkably. Scientists call this age the Devonian Period. It began about 410 million years ago and lasted about 50 million years. During much of this time, dinichthys and other large placoderms ruled the seas.

The first bony fish appeared early in the Devonian Period. They were mostly small or medium-sized and, like all fish of that time, were heavily armoured. These early bony fish belonged to two main groups—*sarcopterygians* and *actinopterygians.*

The sarcopterygians had fleshy or lobed fins. Few fish today are even distantly related to this group. The coelacanth and the lungfish are the only surviving sarcopterygians. In addition, certain scientists include the African bichir in this group. Some scientists believe that among fish, lungfish are the nearest living relatives of land vertebrates. The actinopterygians had rayed fins without fleshy lobes at the base. Among the first actinopterygians were the *chondrosteans,* which differed in many ways from modern ray-finned fish. The chondrosteans were the ancestors of today's ray-finned fish, which make up about 95 per cent of all fish species. The paddlefish and sturgeons are the only surviving chondrosteans, and most scientists believe the bichirs are their nearest relatives.

The first sharks appeared during the Devonian Period. They looked much like certain sharks that exist today. The first rays appeared about 200 million years after the first sharks. By the end of the Devonian Period, nearly all jawless fish had become extinct. The only exceptions were the ancestors of today's lampreys and hagfish. Some acanthodians and placoderms remained through the Devonian Period, but these fish also died out in time.

The first modern fish, or teleosts, appeared during the Triassic Period, which began about 240 million years ago. The chondrosteans of the Devonian Period had given rise to another group of primitive bony fish, the *holosteans.* The holosteans, in turn, became the ancestors of the teleosts. The only surviving holosteans are the bowfin and freshwater gars.

The teleosts lost the heavy armour that covered the bodies of most earlier fish. At first, all teleosts had soft-rayed fins. These fish gave rise to present-day catfish, minnows, and other soft-finned fish. The first spiny-finned fish appeared during the Cretaceous Period, which began about 138 million years ago. These fish were the ancestors of such highly developed present-day fish as perch and tuna. Since the Cretaceous Period, teleosts have been by far the most important group of fish.

A classification of fish

Ichthyologists classify fish into various groups according to the body characteristics they have in common. They divide all fish into two superclasses: (1) *Agnatha,* meaning *jawless,* and (2) *Gnathostomata,* meaning *jawed.* The superclass *Agnatha* consists of two classes of living species that are grouped into two orders. The much larger superclass *Gnathostomata* is divided into classes, subclasses, and orders. The orders are further divided into families, the families into genera, and the genera into species.

Superclass Agnatha. Mouth jawless; **skeleton of cartilage; no paired fins, air bladder, or scales; about 45 species in 2 orders:**


Lamprey (Petromyzontiformes)

Order Petromyzontiformes—lampreys. Large sucking mouth; 7 pairs of external gill openings; some species parasitic; live in salt and fresh water.

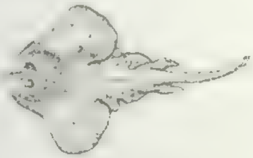
Order Myxiniformes—hagfish. Small nonsucking mouth; 1 to 16 pairs of external gill openings; nonparasitic; salt water.

Superclass Gnathostomata. **Mouth jawed; most species have paired fins and scales; about 21,000 species in 2 classes:**


Blue shark (Squaliformes)

Class Chondrichthyes. Skeleton of cartilage; no air bladder; about 790 species in 3 orders:

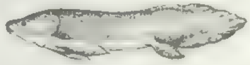
Order Squaliformes—sharks. Most have torpedo shape; upturned tail; 5 to 7 pairs of gill slits; no gill covers; placoid scales; mostly salt water.


Little skate (Rajiformes)

Order Rajiformes—rays. Most have body flattened from top to bottom; whiplike tail; 5 pairs of gill slits under pectorals rather than on sides; no gill covers; placoid scales; mostly salt water.

Order Chimaeriformes—chimaeras. Short-, long-, and elephant-nosed species; pointed tail; 4 pairs of gill slits; gill covers; scaleless; salt water.

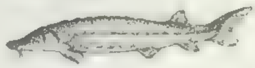
Class Osteichthyes. Skeleton largely or partly bone; most species have 5 pairs of gill slits, gill covers, air bladder, and cycloid or ctenoid scales; over 20,000 species in 2 subclasses:


Australian lungfish (Dipteriformes)

Subclass Sarcopterygii. **Fleshy fins; skeleton partly cartilage and partly bone** (primitive bony); 7 species in 2 orders:

Order Dipteriformes—lungfish. Air bladder an air-breathing lung; fresh water.

Order Coelacanthiformes—coelacanth. Single ancient species; salt water.


Sturgeon (Acipenseriformes)

Subclass Actinopterygii. Rayed fins; skeleton largely or partly bone; single dorsal and anal fins in most orders; over 20,000 species in 34 orders.

Order Polypteriformes—bichirs. Slender body; thick ganoid scales; long dorsal fin composed of separate finlets; lunglike air bladder; fresh water.


Longnose gar (Semionotiformes)

Order Acipenseriformes—paddlefish, sturgeon. Heavy body; paddlefish nearly scaleless; sturgeon have bony plates instead of scales; fresh water; some sturgeon anadromous.

Order Semionotiformes—gars. Long, slender body and jaws; short, far-back dorsal fin, diamond-shaped ganoid scales; lunglike air bladder.

Order Amiiformes—bowfin. Stout body, rounded tail fin; long, wavy dorsal fin; cycloid scales; bony plate under chin; single species.


Bonefish (Elopiformes)

Order Elopiformes—bonefish, tarpon, ten-pounders. Soft fin rays; low pectorals; abdominal pelvics; deeply forked tail; silvery body; mostly salt water.

Order Anguilliformes—eels. Soft fin rays; many species lack pectorals; no pelvics; some species scaleless; snakelike; mostly salt water; some catadromous.


American eel (Anguilliformes)

Order Notacanthiformes—spiny eels. Soft and spiny fin rays; low pectorals; abdominal pelvics; no tail fin; long, tapering body; salt water, on bottom.

Order Clupeiformes—anchovies, herring, sardines, shad. Soft fin rays; low pectorals; abdominal pelvics; deeply forked tail; silvery body flattened from side to side; travel in large schools; mostly salt water.


American shad (Clupeiformes)

Order Mormyriformes—mormyrids. Soft fin rays; low pectorals; abdominal pelvics; many have long snout; electricity-producing organs; fresh water.

Order Osteoglossiformes—bony tongues, fresh-water butterfly fish, mooneyes. Soft fin rays; low pectorals; abdominal pelvics; many have large scales and rounded tail fins; extremely varied body forms; fresh water.

Order Cypriniformes—characins, gymnotid eels, loaches, minnows, suckers. Soft fin rays; most characins have a second, adipose dorsal; most species have low pectorals, abdominal pelvics; air bladder connected to inner ear by series of bones called *Weberian apparatus;* extremely varied body forms; fresh water.


Mormyrid (Mormyriformes)

Order Salmoniformes—dragonfish, mudminnows, pike, salmon, viperfish. Soft fin rays; salmon have a second, *adipose* (fatty and rayless) dorsal fin; most have low pectorals; abdominal pelvics; salt and fresh water.

Order Myctophiformes—lantern fish. Soft fin rays; many species have a second, adipose dorsal; fairly low pectorals; abdominal pelvics; many have light-producing organs; mostly deep salt water.

This table lists the major groups down to the orders into which fish are classified The groups are arranged according to their probable evolutionary development. One or more representative families are listed after the name of each order, along with important characteristics of the fish in the order. The table lists 41 orders. But some ichthyologists list fewer than 41, and others list more. Ichthyologists also disagree on the names of some orders, the way the orders should be arranged, and the species included in each.

Subclass Actinopterygii (continued)

- **Order Siluriformes**—catfish Soft fin rays, but some species have dorsal and pectoral spines; some have a second, adipose dorsal; low pectorals; abdominal pelvics; most scaleless; all have Weberian apparatus and barbels; mostly fresh water.
- **Order Gonorhynchiformes**—sandfish Soft fin rays; low pectorals, pelvics behind abdomen; slender body; beaked snout; primitive Weberian apparatus; salt water.
- **Order Percopsiformes**—cave fish, pirate perch, trout perch. Soft fin rays except for a few spiny rays in pirate perch and trout perch, trout perch have a second, adipose dorsal; low pectorals; pelvics far forward but lacking in most cave fish; large lateral line canals in head; fresh water.
- **Order Batrachoidiformes**—toadfish Spiny and soft fin rays; two dorsal fins—one spiny, one soft; pectorals midway up sides; pelvics under throat; some have light-producing organs; many have poisonous spines; mostly salt water.
- **Order Gobiesociformes**—clingfish Soft fin rays except for single spines in pelvics; pectorals midway up sides; pelvics, under throat, form sucking disk that enables fish to cling to rocks; scaleless; small body; mostly salt water.
- **Order Lophiiformes**—anglers, batfish, frogfish, goosefish. Spiny and soft fin rays; dorsal fin has spiny ray at front, forming dangling lure, pectorals midway up sides, forming fleshy flaps; pelvics under throat or lacking; broad, flat body; many species have light-producing organs; salt water.
- **Order Gadiformes**—cod, eelpouts, pearlfish. Most have soft fin rays; some cod have three dorsals, two anals; high pectorals; pelvics far forward; mostly salt water.
- **Order Atheriniformes**—flying fish, halfbeaks, killifish, needlefish, live-bearing topminnows Most have soft fin rays, pectorals high or midway up sides; abdominal pelvics; near surface of salt, fresh, and brackish water.
- **Order Polymixiformes**—beardfish. Spiny and soft fin rays; pectorals midway up sides; pelvics under chest; forked tail; two chin whiskers; salt water.
- **Order Beryciformes**—pinecone fish, squirrelfish. Spiny and soft fin rays; pectorals midway up sides; pelvics under chest; brilliantly coloured; salt water.
- **Order Zeiformes**—boarfish, dories. Spiny and soft fin rays; pectorals midway up sides, pelvics under chest; body extremely flattened from side to side; upturned mouth; salt water.
- **Order Lampridiformes**—crestfish, oarfish, opahs, ribbonfish. Soft fin rays; many species have unusually long dorsal and anal fins; pectorals midway up sides; pelvics under chest or lacking; varied body forms; salt water.
- **Order Gasterosteiformes**—pipefish, sea horses, sticklebacks, trumpetfish. Spiny and soft fin rays, pectorals midway up sides; pelvics under chest; slender body; tubular snout; many encased in bony plates or rings, salt and fresh water.
- **Order Channiformes**—snakeheads. Soft fin rays; low pectorals; pelvics under chest or lacking; special air-breathing organs; fresh water.
- **Order Scorpaeniformes**—scorpionfish, sculpins. Spiny and soft fin rays; usually two dorsals—one spiny, one soft, pectorals midway up sides; pelvics under chest; cheek covered by bony plate; many have extremely sharp, poisonous spines; varied body forms; salt and fresh water.
- **Order Pegasiformes**—sea moths. Spiny and soft fin rays; large, spiny, winglike pectorals high on sides, small pelvics between chest and abdomen; small body encased in bony plates and rings; extended snout; salt water.
- **Order Dactylopteriformes**—flying gurnards. Spiny and soft fin rays; two dorsal fins—one spiny, one soft, huge, winglike pectorals midway up sides; pelvics under chest, head encased in heavy bone; salt water.
- **Order Synbranchiformes**—swamp eels. Soft fin rays; dorsal and anal fins rayless; no pectorals; pelvics under throat or lacking; gill openings under head; special air-breathing organs, eel-shaped body; fresh and brackish water.
- **Order Perciformes**—bass, blennies, gobies, jacks, mackerel, perch Spiny and soft fin rays, many have two dorsal fins one spiny, one soft, pectorals midway up sides; pelvics under chest and composed of one spine and five soft rays in most species; extremely varied body forms; largest fish order, with 8,000 to 10,000 species; salt and fresh water.
- **Order Pleuronectiformes**—flounders, soles, tonguefish. Most have soft fin rays; long dorsal and anal fins; pectorals and pelvics small or lacking; flattened body; adults have both eyes on same side of head; mostly salt water.
- **Order Tetraodontiformes**—boxfish, ocean sunfish, puffers, triggerfish Spiny and soft fin rays; pectorals midway up sides, pelvics under chest or lacking, scaleless or covered with spines, bony plates, or hard scales, many are poisonous to eat; varied body forms; mostly salt water.


Blue catfish (Siluriformes)


Trout perch (Percopsiformes)

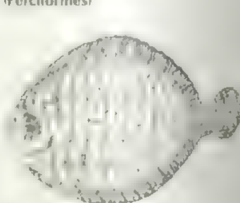

Goosefish (Lophiiformes)


Flying fish (Atheriniformes)


Oarfish (Lampridiformes)


Snakehead (Channiformes)


Common jack (Perciformes)


Naked sole (Pleuronectiformes)

Related articles in *World Book* include:

Freshwater fish

Alewife
Anableps
Archerfish
Bass
Blindfish
Bowfin
Buffalo fish
Bullhead
Carp
Catfish
Chub
Crappie
Darter
Drum
Eel
Electric eel
Electric fish
Fightingfish
Gar
Goldfish
Grayling
Lamprey
Lungfish
Minnow
Muskellunge
Paddlefish
Perch
Pickerel
Pike
Piranha
Pupfish
Roach
Salmon
Sculpin
Smelt
Stickleback
Sturgeon
Sucker
Sunfish
Trout
Whitefish

Saltwater fish

Alewife
Amberjack
Anchovy
Angelfish
Barracuda
Bass
Blackfish
Bluefish
Bonefish
Bonito
Bream
Butterfish
Candlefish
Catfish
Cod
Coelacanth
Cutlassfish
Doctorfish
Dogfish
Dolphin
Drum
Eel
Electric fish
Flatfish
Flounder
Flyingfish
Grouper
Grunion
Grunt
Gurnard
Haddock
Hagfish
Hake
Halibut
Herring
Jewfish
Kingfish
Lamprey
Lanternfish
Lumpfish
Mackerel
Marlin
Menhaden
Mullet
Oarfish
Pilotfish
Pipefish
Pompano
Porcupinefish
Porgy
Puffer
Ray
Redfish
Remora
Rosefish
Sailfish
Salmon
Sardine
Sawfish
Sculpin
Seahorse
Shad
Shark
Skate
Smelt
Snapper
Sole
Spot
Sprat
Stickleback
Stingray
Sturgeon
Swordfish
Tarpon
Tilefish
Toadfish
Torpedo ray
Triggerfish
Trout
Tuna
Turbot
Wahoo
Weakfish
Wolffish

Other related articles

Animal (pictures)
Aquaculture
Aquarium
Evolution
Fishing
Fishing industry
Food supply (Live stock and fish)
Fossil (picture: Fish skeleton)
Grand Banks
Ichthyology
Instinct
Ocean (Life in the ocean; pictures)
Plankton
Prehistoric animal
Reproduction (Sexual reproduction in animals)
Sea serpent
Spawn
Tropical fish

Outline

I. The importance of fish
A. Food and game fish
B. Other useful fish
C. Harmful fish
D. Fish in the balance of nature

II. Kinds of fish
A. Bony fish
B. Sharks, rays, and chimaeras
C. Lampreys and hagfish

III. Where fish live
A. Saltwater environments
B. Freshwater environments
C. Fish migrations

IV. The bodies of fish
A. External anatomy
B. Skeleton and muscles
C. Systems of the body
D. Special organs

V. The senses of fish
A. Sight
B. Hearing
C. Smell and taste
D. Touch and the lateral line system
E. Other senses

VI. How fish live
A. How fish get food
B. How fish swim
C. How fish protect themselves
D. How fish rest
E. How fish live together
F. How fish adjust to change

VII. How fish reproduce
A. Preparation for spawning
B. Spawning and care of the eggs
C. Hatching and care of the young

VIII. The development of fish
A. The first fish
B. The Age of Fishes
C. The first modern fish

IX. A classification of fish

Questions

What kind of food do most fish eat?
How are lampreys and hagfish different from other fish?
What are *median fins*? *Paired fins*? *Chromatophores*?
How great a change in water temperature can most fish survive?
What is the name of the process by which most fish eggs are fertilized?
Which parts of the world have the most species of freshwater fish?
What were *ostracoderms*?
How do fish turn and make other swimming manoeuvres?
What are the two main groups of jawed fish? How do they differ?

Fish farm. See **Fish** (Food and game fish).

Fish hawk. See **Osprey**.

Fish ladder. See **Salmon** (The life of a salmon).

Fisher. See **Marten**.

Fisher, Andrew (1862-1928), was prime minister of Australia three times—in 1908 and 1909, from 1910 to 1913, and in 1914 and 1915. Born at Crosshouse, in Scotland, he sailed to Australia in 1885. He was elected to the Queensland Legislative Assembly as member for Gympie in 1893. He represented Wide Bay, Queensland, in the federal Parliament from 1901 until he retired. He was minister for trade and customs in the first federal Labor government in 1904. In 1907, he was elected leader of the federal parliamentary Labor Party.

Fisher's governments aimed to consolidate the federation of Australia and to build it up as a nation. During World War I (1914-1918), Fisher became famous for his slogan: "To the last man and the last shilling." He introduced compulsory military training but did not support conscription.

Important legislation of the Fisher governments included setting up the Commonwealth Bank and commencing the transcontinental railway, worker's compensation, tariff protection for Australian industry, and federal control of shipping.

Fisher, Geoffrey Francis (1887-1972), Baron Fisher of Lambeth, was archbishop of Canterbury and primate of all England from 1945 until 1961. As archbishop, he did much to improve the organization and administra-

tion of the Church of England after World War II (1939-1945). He also helped with the revision of church law. He worked for the closer association of churches in Britain and throughout the world, and he served as a joint president of the World Council of Churches. He was the first Church of England archbishop to visit the Pope since the Reformation. He officiated at the coronation of Queen Elizabeth II, in 1953. Fisher was born at Higham-on-the-Hill, Leicestershire, England.

Geoffrey Fisher

Fisher, H. A. L. (1865-1940), was a British historian, politician, and educationist. His most important historical work was his *History of Europe*. As president of the Board of Education, he attempted in the 1918 Education Act to extend the national system of education by making part-time education available to all children beyond school. But financial difficulties prevented the measure from being put into effect. Herbert Albert Laurens Fisher was born in London.

Fisher, John Arbuthnot (1841-1920), was a British admiral. He joined the Royal Navy in 1854 and served during the Crimean War (1853-1856). He became first sea lord of the Admiralty in 1904. His reforms included a change from coal-burning to oil-burning warships, and the introduction, in 1906, of the *Dreadnought* class of battleship. See **Battleship.**

In 1909, Fisher was given the title of Baron Fisher of Kilverstone. He retired in 1910, but was recalled as first sea lord in 1914, on the outbreak of World War I. Fisher resigned in 1915, after opposing the Allied landings in Gallipoli (see **World War I**).

John A. Fisher

Fisher, Saint John (1469?-1535), was a Roman Catholic bishop of Rochester, England. He was beheaded for saying that King Henry VIII was not the supreme head of the church in England. Fisher was born in Beverley, near Hull, England, and was educated at Cambridge University. He was ordained a priest in 1491. He later founded St. John's College at Cambridge. Fisher was also a learned theologian who wrote many important books. While he was awaiting death in prison, Pope Paul III made him a cardinal. His feast day is July 9.

Fisher, Sir Ronald (1890-1962), a British statistician and geneticist, developed statistical methods on which much modern research and experiment are based. His writings on the use of statistics in research include *Statistical Methods for Research Workers* (1925) and *The Design of Experiments* (1935). He also contributed to genetical theory. Fisher was born in London and educated at Cambridge University, in England.

Fisher, Sylvia (1910-), an Australian soprano, became a principal singer at the Royal Opera House, Covent Garden, in London. Sylvia Gwendoline Victoria Fisher was born in Melbourne. She won the *Sun* aria contest in Melbourne in 1936. She first sang at Covent Garden in 1948, and remained a member of the ensemble until 1958. She scored a notable success in the role of the Kostelnicka in the first British production of *Jenufa* in 1956. She began singing with the English Opera Group in 1963. In 1966, she played Elizabeth I in the revival of *Gloriana* at Sadler's Wells, in London.

Sylvia Fisher

Fisher's ghost is the subject of an Australian legend dating from the 1820's. On the night of June 17, 1826, Frederick Fisher disappeared from his farm at Campbelltown, in New South Wales. His employee, George Worrall, told friends that Fisher had fled to Britain to escape a charge of forgery. But a few months later, another farmer, John Farley, claimed that he had seen Fisher's ghost sitting on a fence and pointing to a field nearby. Policemen later found Fisher's body in a shallow grave at the spot Farley said the ghost had indicated. George Worrall confessed to the murder of Fisher and was eventually hanged for his crime.

Fishery is an area which supplies abundant fish for commercial purposes. Inland fisheries include lakes, rivers, and fish farms. Most of the world's fishing catch comes from sea fisheries. Species of cod, flatfish, herring, sardines, and tuna make up the world's most important fishery resources. Many governments practise *fishery management* to conserve fish. Rules limit the size and amount of fish that may be caught, and the fishing season. See also **Fishing industry.**

Fishes, Age of. See **Devonian Period.**

Fishing is one of the most popular forms of recreation. People of all ages enjoy fishing in streams, rivers, lakes, bays, and seas for many *species* (kinds) of fish.

Some people fish with simple cane poles, but others use rods, reels, and additional equipment that requires more skill to operate. People who fish for sport are called *anglers.* They enjoy the challenge of hooking and landing fish. Many anglers try to catch certain species of fish. Some fish are especially prized for their beauty. Others are unusually strong or fast and fight hard to escape. Some species are considered crafty game that must be outwitted in order to catch them.

Some common methods of fishing include casting, still fishing, drift fishing, trolling, and float fishing. *Casting* is one of the most popular methods. The angler casts the *lure* (artificial bait) into the water and carefully *retrieves* (gathers in) the line in an attempt to lure a fish to bite. In *still fishing,* the angler throws the bait into the water from a bank or anchored boat and waits for a fish to bite. When *drift fishing,* the angler trails the bait behind a boat which is allowed to drift freely with the current. In *trolling,* the bait is trailed behind a moving boat. In *float fishing,* the bait is suspended below the float.

This article discusses recreational fishing. For information on commercial fishing, see **Fishing industry.**

Fishing equipment

Manufacturers produce a wide variety of *tackle* (equipment) designed for every type of fishing. Fishing tackle includes rods, reels, lines, leaders, sinkers, floats, hooks, and bait. The choice of equipment depends chiefly on the kind of fish sought.

Rods are tapered poles made of fibreglass or graphite. Graphite rods are the most popular because they are lightweight yet strong and flexible.

Rods are made in many lengths, weights, and designs. Each rod is designed for use with a particular type of reel. For example, a fly rod is used with a fly reel. Rods also vary in *action* (flexibility), ranging from limber to stiff. Rods with greater flexibility are needed to catch larger fish.

Reels are used to store, release, and retrieve fishing line. There are four basic kinds of reels: (1) spinning, (2) multiplying, (3) bait-casting, and (4) fly. Each kind of reel is manufactured in various sizes and designs. Spinning reels are the easiest to use and the most popular.

Spinning reels have an open-faced spool mounted on the reel seat in a vertical position parallel to the rod. The spool does not turn when the line is cast or retrieved. When cast, the line simply slips off the open end of the spool. Spinning reels have a handle for gathering in line. A device called a *bail* winds the line around the spool. The spool moves in and out of its frame so that the line is wound evenly. The spool itself turns only when a fish pulls on the line against the drag setting.

Multiplying reels are used mainly for beach or open sea fishing. They are geared internally so that one turn of the reel handle turns the spool 2 to 4 times. This gives the reel a high line retrieval rate. Multiplying reels are fitted with so-called star or lever drag systems, which apply greater or lesser pressure to a hooked fish.

Bait-casting reels have a wide spool that lies horizontally across the reel seat. The reel has a handle that turns to release and retrieve line. For each turn of the reel handle, the spool revolves several turns.

Fly reels serve chiefly to store line and to feed line to a hooked fish. A fly reel is not designed to cast line. In fly casting, the line is pulled off the reel by hand and cast into the water with the rod.

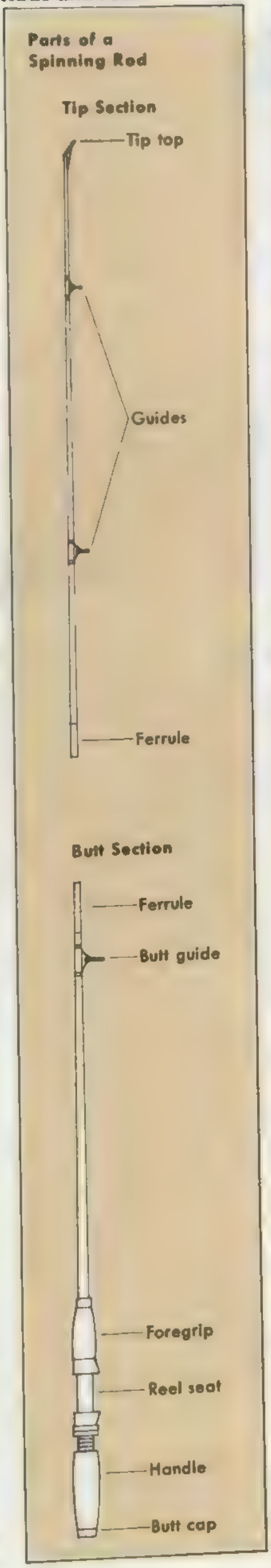
Lines may consist of natural fibres, such as linen and silk, or synthetic fibres, such as nylon or Dacron. Some lines are made of many fibres braided or twisted together. Others consist of *monofilaments,* which are single strands of fibre.

Monofilament lines are widely used on spinning, multiplying, and bait-casting reels. These lines are sturdy and lightweight. Braided lines are often used with fly reels. These lines are heavier than monofilament lines. Their extra weight is essential in fly casting because it helps carry the line smoothly through the air.

Lines are rated in *pounds test,* which is the weight they can lift without breaking. The weight and strength of the line used depends on the size of the rod and reel and the kind of fish sought.

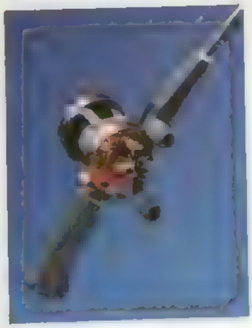
Leaders are lengths of line made of a synthetic or metal material. A leader is connected to the end of a line and attached to a hook. Synthetic monofilament leaders

Rods and reels



Spinning reel

Multiplying reel



Bait-casting reel

Fly reel

Some basic types of lures

A popping plug floats on top of the water. When the rod is jerked, the plug's hollowed mouth goes underwater and makes popping sounds that attract fish.

A spinner has a metal blade that spins as it is drawn through the water. Spinners attract fish by their motion, vibration, and bright flashing colours.

Flies are made of feathers, hair, or other materials. A wet fly, *left,* sinks below the surface of the water. A dry fly, *right,* floats on the surface.

A floating and diving plug floats on the surface of the water until the line is *retrieved* (gathered in). The plug then dives below the surface.

A plastic worm can be made to slide or hop along the bottom of the water by slowly retrieving the line. It does not catch on weeds as easily as other lures.

A streamer fly has a long wing made of feathers or hair. It is designed to imitate a small bait fish. Most streamer flies sink below the surface.

A deep diver plug dives quickly while the line is being retrieved. It may dive to a depth of 3 to 6 metres or more.

A jig sinks quickly after hitting the water. As the rod is jerked, a jig attracts fish by making short, rapid hops along the bottom of the water.

A spoon flutters or wobbles when pulled through the water. The action of this type of lure is designed to imitate that of a wounded bait fish.

are used with braided lines because they provide a less visible link between the line and the hook. Metal leaders are used when casting for sharp-toothed or rough-scaled fish that may break a line. Leaders range in length from 30 centimetres to about 4 metres or longer. A leader may be attached to a line with a device called a *swivel.* A swivel allows the leader to rotate freely and thus prevents twisting of the line and leader.

Sinkers are lead weights that are attached to lines or leaders. They lower the bait and hold it in the water. An angler selects a sinker that is just heavy enough to hold the bait at the desired depth. Sinkers also provide extra weight on the line, enabling it to be cast farther. Sinkers are made in various styles designed for waters with rocky, muddy, or sandy bottoms. They range in weight from about 1.8 grams to 1.4 kilograms.

Floats hold the bait suspended in the water. They are made of cork, plastic, or some other material that floats. Some floats can be partially filled with water to give additional weight when casting. The amount of line between the float and the bait determines the depth at which the bait is suspended. The float will bob when a fish bites the hook.

Hooks are made in many sizes and hundreds of styles. The choice depends on several factors, such as the kind of tackle used and the size of fish sought.

Bait used to catch fish may be either natural or artificial.

Natural bait. Most freshwater and saltwater game fish feed chiefly on smaller fish. Therefore, a small live fish on a hook is one of the best kinds of natural bait.

Fish also feed on such animals as worms, crayfish, grasshoppers, and frogs, all of which are used as live bait in freshwater fishing. Eels, clam worms, and shrimp may be used in saltwater fishing.

Many species of fish feed on dead animals as well as live ones. Such fish can be caught with *cut bait,* which consists of pieces of dead fish. Anglers also use cheese, fish eggs, and bread dough as bait.

Artificial bait consists of a variety of items called *lures.* Some lures look like natural bait, and others attract fish by means of their unusual colour, design, motion, or sound. Lures, unlike natural bait, can be reused and can be cast further and harder. Basic types of lures include *flies, plugs, spinners,* and *spoons.*

Flies are lightweight lures made of feathers, hair, yarn, or other materials tied onto a hook. Some flies look like insects, small fish, or other natural food of fish. Others attract fish by their unusual colour or appearance. There are two basic types of flies, *wet flies* and *dry flies.* Wet flies sink beneath the surface of the water. Dry flies float.

Plugs are wooden or plastic lures designed to resemble small fish, frogs, and other natural bait. There are two chief kinds of plugs, *surface plugs* and *sinking plugs.* Surface plugs float on top of the water. Some sinking plugs sink when they hit the water, and others dive to various depths while the line is being retrieved. Many plugs twirl, wobble, or make popping or gurgling sounds to attract fish.

Spinners have metal or plastic blades that whirl as the spinner is retrieved through the water. They attract fish by their colour, motion, and the sound they make. Spinners also work well in cloudy water, where fish might not notice silent lures. They may be used alone or with other lures or natural bait.

Spoons are rounded or dished-out metal lures that flutter when pulled through the water. Their action imitates that of wounded bait fish.

Other equipment includes *creels, nets, tackle boxes,* and *electronic devices.* Creels are canvas, rattan, or willow containers used to carry fish. Long nets called *keepnets* are used to retain the fish. Smaller round or triangular nets are used to land hooked fish. Tackle boxes hold lures, hooks, and other equipment. Some anglers use electronic devices that measure the depth and temperature of the water or even locate fish.

Fishing tips

Successful fishing requires much practice and study. A person can learn only from experience how to hook and *play* (tire out) a fish properly. To catch a particular species of fish, an angler must study its habits—what it eats, the kinds of waters it lives in, and the water depth and temperature it prefers.

The habits of a fish influence the choice of bait, the fishing technique used, and the place chosen for fishing. For example, rainbow trout thrive in cool, clear streams with swift currents. They often feed near the surface of the water, where the current brings them insects to eat. A favourite method of catching these fish is fly fishing, using a fly rod and reel with a dry fly, casting upstream. Other fish live in muddy lakes and streams near the bottom of the water. They find their food chiefly by smell or touch. Such fish may be caught by fishing near the bottom of the lake or stream and using an odorous bait made of cheese, meat, or bread dough.

The temperature of the water influences the hunger and activity of fish. Each species prefers a certain temperature range. Fish become less active when the temperature is above or below their preferred range. Certain species may wait until night or early dawn to feed if the water temperature near the surface is too warm. Anglers often measure the water temperature at various depths to find the level suitable for the fish they seek.

Fishing as a sport

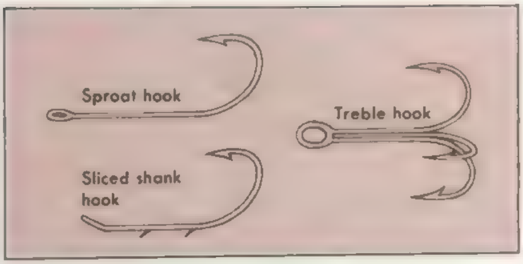
Fishing in Britain and Ireland. More than 4 million people in Britain and Ireland enjoy fishing as a pastime.

Game fishing in Britain and Ireland refers to fishing for trout, salmon, and grayling. These fish frequent only the purest waters.

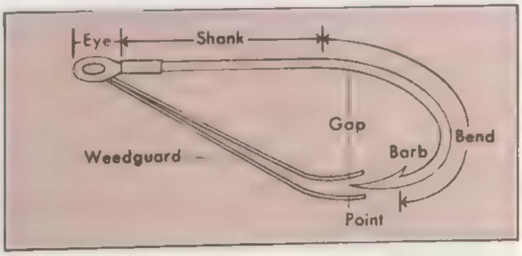
Trout is the most widely distributed game fish in Britain and Ireland. There are two kinds of trout: *migratory trout* and *nonmigratory trout.* Migratory trout spend the early part of their lives in fresh water, and then migrate to the sea. They return to fresh water to *spawn* (lay eggs). Migratory trout are called *sea trout.* Nonmigratory trout live all their lives in fresh water. They are of two varieties: *brown trout* and *rainbow trout.*

Many species of salmon are found in various parts of the world. The species that lives in British and Irish waters is called the *Atlantic salmon.* These salmon come from the sea to breed in the upper reaches of clear, fast-flowing rivers. Anglers catch them with a lure, such as a fly, as they make their way upstream. Salmon do not feed after they leave the sea. Scientists do not know why a salmon is tempted to seize an angler's lure. Some people believe that a salmon instinctively attacks any lifelike object moving in the water.

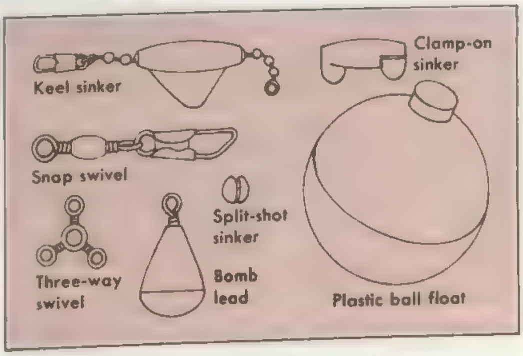
Some popular bait hooks



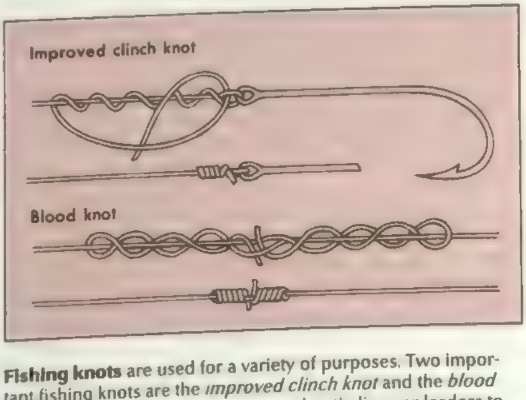
Parts of a fishhook



Some fishing tackle



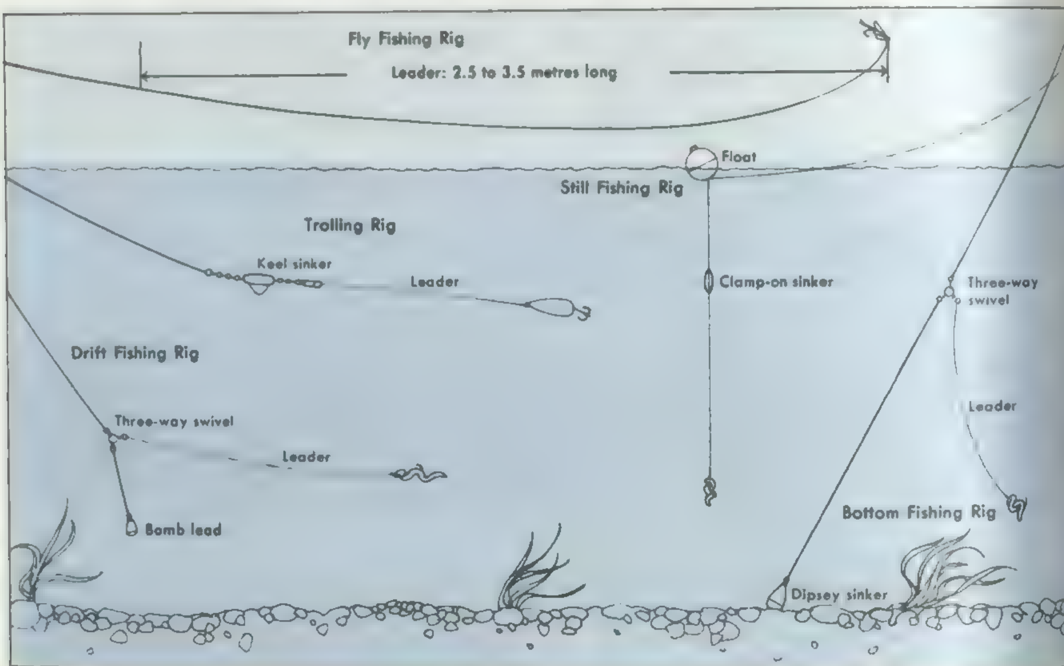
Two basic fishing knots



Fishing knots are used for a variety of purposes. Two important fishing knots are the *improved clinch knot* and the *blood knot.* An improved clinch knot is used to tie lines or leaders to hooks, lures, or *swivels.* Swivels are attachments that allow a line or leader to rotate freely and thus prevent twisting of the line or leader. A blood knot is used to join two lines or two leaders together.

Five ways to rig a fishing line

The illustration below shows five of the many ways of rigging a fishing line. For fly fishing, the line may be rigged with a long leader. For bottom fishing, drift fishing, and *trolling* (fishing from a moving boat), sinkers are used to hold the bait or lure at the proper depth. In *still fishing* (fishing from a shore or anchored boat), a float may be used to suspend the bait in the water.



Grayling are mainly silver-grey in colour. They live in waters similar to those in which salmon and trout are found. Grayling are related to salmon and trout, but differ from them in their habits, breeding during the spring, not during the winter.

Coarse fishing. All British freshwater fish, except salmon, trout, and grayling, are known as *coarse fish.* Coarse fish include barbel, bream, carp, chub, dace, perch, pike, roach, rudd, and tench. As a rule, these fish live in the middle and lower reaches of rivers and streams, and in canals, lakes, and ponds.

The main methods of fishing for coarse fish are casting, float fishing, and still fishing. The method of fishing anglers use depends on the kind of fish they want to catch. Some coarse fish, such as carp, chub, and rudd, feed near the surface of the water. Others, such as bream, roach, and tench, feed near the bottoms of lakes and rivers. As a result, an angler must choose the right bait and set it at a suitable depth for these fish.

The most widely used baits are bread, worms, and maggots. Most kinds of coarse fish may be caught with these baits. But, for pike fishing, many anglers use live bait such as small dace, gudgeon, or minnow. Anglers also fish for pike with lures such as spinners and plugs.

Sea fishing. Anglers catch many species of saltwater fish with rod and line along the coasts of Britain and Ireland. Most sea anglers fish from beaches, rocks, or piers. The main species of fish they catch are bass, cod, dab, flounder, mackerel, mullet, plaice, pollack, pouting, sole, whiting, and wrasse. Anglers use boats when they wish to catch fish that live in deeper waters. These fish include dogfish, shark, skate, and tope.

Anglers who fish in the sea use stronger tackle than those who fish in fresh water. Anglers who fish from a rock or pier may have to cast their baited hook a distance of up to about 100 metres to ensure that it reaches water of a suitable depth. Anglers who fish from a boat need not cast their line.

As a rule, the autumn and winter months are the best for sea fishing. But anglers take good catches of bass, mullet, and wrasse during the summer. Flatfish live on a smooth, sandy seabed. As a result, anglers catch large numbers of these fish in waters close to the shore. The baits that sea anglers use include lugworms, ragworms, mussels, soft crabs, and sand eels. They also use strips of fish such as herring and mackerel for bait.

Fishing in Australia and New Zealand. In Australia, people from all over the world flock to Cairns, in Queensland, for big-game fishing. The city has become the international centre for black marlin fishing, anglers having caught specimens weighing more than 700 kilograms. Other fish sought include snapper and Spanish mackerel, off Queensland, and sailfish, off Western Australia. The biggest catches are white sharks, off South Australia. Several of these fish weighing more than a metric ton each have been caught with rod and line.

In New Zealand, the leaping marlin, marko shark, swordfish, and tuna offer some of the most thrilling deep-sea fishing in the world. Freshwater anglers go to New Zealand to fish for the exceptionally large trout in the thermal waters of Lake Taupo, the Tongariro River, and Lake Rotorua.

See also **Fish; Fishing industry.**

Fishing banks. See **Grand Banks.**

Various types of fishing gear and vessels are used to catch fish. Much of the world's commercial catch is harvested with huge nets like the one being used on the left to haul in tuna. Many fishing vessels, such as the Russian *stern trawler* above, also carry equipment on board to process fish after they have been caught.

Fishing industry

Fishing industry is an important economic activity that provides food and jobs for millions of people. The fishing industry includes all the activities involved in the commercial and recreational production of fish and shellfish. The catching, processing, marketing, and conservation of fish and shellfish are all parts of the industry. The industry also provides various other products from the sea, such as seaweed.

Fish are an excellent source of protein, one of the chief *nutrients* (nourishing substances) that people need for a good diet. As the world's population has grown, so has the demand for food—especially food rich in protein. The fishing industry has increased its annual catch to help meet this demand. The industry markets food fish in a variety of forms. The fish are sold fresh, canned, cured, and frozen. In addition, about a fourth of the world's fish catch is used to produce high-quality animal feed and various industrial products.

The seas are by far the main source of fish. About 13 per cent of the world's commercial fish catch comes from such inland waters as lakes and rivers. About 10 per cent comes from *fish farms.* Fish farms are enclosures built on land, or areas in natural bodies of water where fish and shellfish are raised for food.

The fishing industry catches many kinds of fish. Such fish as anchovies, capelin, herring, mackerel, sardines, and tuna are caught near the surface of seas. Such fish as cod, flounder, hake, and pollock are harvested near the sea floor. Freshwater fish, such as carp, catfish, and whitefish, are caught in inland waters. Carp and catfish may also be raised on fish farms.

In the late 1980's, the worldwide fish catch totalled about 93 million metric tons annually. Japan was the leading fishing country, with a catch of over 11 million metric tons in 1987. The world's average yearly catch had increased greatly since the early 1960's, when it was little more than 40 million metric tons.

The fishing industry employs about 6 million people worldwide. These people work on ocean-going fishing boats, coastal craft, or small boats, and increasing numbers are engaged in inland fisheries. Almost as many people work in related industries, building fishing vessels or manufacturing fishing equipment. They process, package, sell, and distribute fishery products. They have such varied jobs as buying fish, filleting fish, *shucking* (opening and cutting) oysters, operating canning machines, and inspecting markets to enforce pure-food regulations.

In the early 1950's, the developing countries of the world accounted for little more than one-third of the total international fish catch. Since 1985, these countries have harvested more sea and inland fish than the industrial countries. In 1988, developing countries caught slightly more than half the total catch, while the industrial nations' catch was slightly less than half. But the average consumption of fish per person in the developing countries was only just over 8 kilograms, while in the industrial countries it was 12.4 kilograms.

The largest fish consumers among industrial nations are the Japanese, who eat an average of 70 kilograms per person per year. The South Atlantic Island of St. Helena, with only 8,000 inhabitants, heads the world table, with an average yearly consumption of nearly 100 kilograms per person. In Portugal and Spain, people eat more fish than anywhere else in the European Community. The Portuguese eat an average of 43 kilograms of fish a year, the Spanish an average of 33 kilograms of fish a year.

People have fished for thousands of years. Evidence of fishing has been found in prehistoric lake dwellings. The ancient Phoenicians and Greeks developed fleets of

ships for fishing and trading. The ancient Egyptians made nets of the finest grades of twine, spun from flax. In the Middle Ages, inland and sea fish were even more important as food in some countries than they are today. Fish oil was widely used as fuel for lamps. For hundreds of years, people have used hooks, spears, nets, and traps to capture fish. Such equipment is still used, but commercial fishing crews now harvest most of their catch with huge nets. In addition, modern fishing vessels have various devices that make fishing more efficient. For example, advanced navigational aids and fish-finding equipment such as radar and sonar enable fishing crews to range far from their home ports and to pinpoint schools of fish. Refrigeration systems aboard the vessels help prevent the catch from spoiling. This means that these vessels can remain at sea much longer than those without refrigeration.

After World War II ended in 1945, many countries expanded their fishing fleets. These fleets increased their fish catch along their home coasts as well as in distant waters. As a result, the fish harvest generally increased each year. At the same time, however, overfishing severely reduced the stocks of some kinds of fish. Disputes also arose among countries over the ownership of fish resources.

Traditionally, fish have been considered common property—that is, no one owned them until they were caught. The fish then became the property of whoever caught them. After the development of long-range fishing fleets, many nations wanted to protect the fish resources along their coasts from fleets of other countries. As a result, a number of international commissions were formed to promote fish conservation and to help settle disputes over fishing rights.

During the 1970's, almost all nations bordering the sea established *fishery conservation zones,* also known as *exclusive economic zones,* in further efforts to conserve and protect their fish resources. These zones extend 200 nautical miles (370 kilometres) from a nation's coast. Countries that have adopted such zones claim authority over all fishing—and ownership of all fish—within the zones.

Where fish are caught

Areas where fish are caught commercially or recreationally are called *fisheries.* In many cases, more than one species of fish is harvested from a particular fishery. A fishery may be a small lake. Or it may extend across an enormous section of an ocean. For example, the tuna fishery that lies off the west coast of Central and South America covers about 13 million square kilometres.

Sea fisheries provide most of the world's commercial fish catch. About 90 per cent of the total world harvest is taken from the sea annually. This figure includes the production from marine fish farms. Almost all the marine catch comes from waters near sea coasts, especially the shallow waters over the *continental shelf.* The continental shelf consists of submerged land along the coasts of the continents. In some places, the shelf extends great distances out into the sea.

A large amount of the fish caught in waters over the continental shelf is taken from regions of *upwelling.* Upwelling occurs during certain seasons when winds blow surface waters near the coast offshore. The colder bot-

Chief commercial fishing areas

This map shows the world's major commercial fishing areas. Most lie along the *continental shelf,* the submerged land around the continents. Inland fishing areas include rivers and lakes. The map also shows the chief fish and shellfish, with the most valuable catches in boldface type.

Leading fishing countries

Figures are for 1987.
Source: *Yearbook of Fishery Statistics, 1987,* Food and Agriculture Organization of the United Nations.

Worldwide fish and shellfish catch

Chief kinds	Annual catch in metric tons
Sardine and pilchard	11,700,000
Pollock	7,200,000
Anchovy and anchoveta	4,520,000
Jack mackerel	4,490,000
Cod	2,500,000
Tuna	2,350,000
Mackerel	2,300,000
Squid and octopus	2,270,000
Clam	2,170,000
Shrimp and prawn	2,070,000
Herring	1,910,000
Hake	1,710,000
Crab	1,460,000
Flounder and sole	1,280,000
Menhaden	1,240,000
Capelin	1,110,000
Oyster	1,030,000
Sand lance	967,000
Mussel	901,000
Salmon	630,000

Figures are for 1987.
Source: *Yearbook of Fishery Statistics, 1987,* Food and Agriculture Organization of the United Nations.

tom waters, which are rich in nutrients, then rise to the surface near the coast. This upwelling of bottom waters provides nutrients for the growth of microscopic plants and animals that fish feed on, thus promoting growth of the fish population. Upwelling takes place chiefly along the coasts of Peru, western North America, northwest and southwest Africa, Somalia, the Arabian Peninsula, and Antarctica.

Of the upwelling fisheries, the Peruvian is the best-known. The cold Peru (or Humboldt) current brings about upwelling with a massive increase in the food available for fish. Annual catches of a single species of anchovy, the anchoveta, have amounted to more than 13 million metric tons. This was at the height of the Peruvian fishery boom in the early 1970's, and at that time was about 15 per cent of the total world fish catch. Anchoveta is used for animal feed and fertilizer.

Atlantic Ocean fisheries. More than a third of the world's marine catch comes from the Atlantic Ocean. The North Atlantic is the most productive area. The major fisheries in the Atlantic include the coastal waters from Newfoundland, Canada, to New England, U.S.A., and the *Grand Banks.* The Grand Banks is a stretch of shallow waters southeast of Newfoundland. The Grand Banks and the other waters of the northwest Atlantic rank among the best fishing grounds in the world. The area provides great quantities of cod and herring, as well as flounder, lobsters, and scallops.

Cod from the northwest Atlantic is the chief catch of the Canadian fishing industry. Canada also leads the world in the production of Atlantic herring.

The Gulf of Mexico, an arm of the Atlantic Ocean, is a productive area for the U.S. fishing industry. It ranks as the main U.S. fishery for catching menhaden. The Gulf of Mexico also provides large quantities of shrimp and lobsters.

The Atlantic Ocean has several other rich fishing areas. They include the northeast Atlantic near Iceland and the United Kingdom (UK), and the southwest Atlantic near Argentina and Brazil. Crews from a number of nations—including Denmark, Iceland, Norway, Russia, and the UK—fish the waters of the northeast Atlantic. They catch capelin, cod, haddock, herring, mackerel, and many other types of fish. The chief fish caught in the southwest Atlantic Ocean include croaker, hake, and sardines.

Around the British Isles, the waters are fairly shallow within the limits of the continental shelf. Both the UK and the Republic of Ireland have fishing fleets, together employing about 30,000 people on a full- or part-time basis. Vessels range from large factory trawlers with crews of about 60, to small, one-person boats. Deep-sea fishing declined in the 1970's, and now many vessels fish for herring off the western coasts of Britain and Ireland. Near- and middle-water trawlers operate in the North Sea and the Atlantic. Inshore vessels include *seiners,* named after the nets they use, and light trawlers. Coastal fishing vessels fish for molluscs, such as cockles and mussels; and crustaceans, such as crab, lobster, and prawns. The fish caught by coastal fishing vessels include haddock and plaice.

As members of the European Community, the UK and Ireland maintain a 320-kilometre limit around their shores. Ships from non-Community countries are allowed restricted fishing rights within the limit. The Community has a common fisheries policy.

Pacific Ocean and Indian Ocean fisheries. More than half the world's total marine catch is from the Pacific Ocean. The North Pacific is the most productive area. The chief fish caught in the Bering Sea, the Gulf of Alaska, and other areas of the North Pacific include hake, pollock, salmon, and sole. The United States is the leading salmon-fishing country. Next come Japan, the fleets of the former Soviet Union, and Canada.

The Pacific Ocean also has a number of other productive fisheries. They include the waters of the southeast Pacific off the coast of South America and the coastal seas of the western Pacific from Indonesia to Japan. The fisheries off the west coast of South America provide anchovetas, hake, mackerel, and sardines. The coastal seas from Indonesia to Japan are fished for anchovies, mackerel, sardines, scad, shrimp, and tuna.

The Philippines' fishing industry catches anchovies, mackerel, sardines, scad, and tuna in offshore waters. South Korea is one of the world's leading fishing countries, with fleets fishing in the deep Pacific waters.

Both Indonesia and Malaysia have extensive fishing fleets, mainly small boats which fish for mackerel, prawns, scad, and tuna. Indonesia also has a valuable trade in ornamental fish.

Australia has relatively limited fishing resources. Although thousands of fish species live in its coastal waters, few of them are both plentiful and good to eat. The small Australian fishing industry catches shellfish, especially abalone, lobsters, oysters, shrimp, and scallops. Mullet, salmon, and tuna are also caught. The chief fish caught in New Zealand waters include barracuda, hobi, orange roughy, red cod, and snapper.

India is a major fishing nation. Croakers, mackerel, sardines, sharks, and shrimp are the main species caught in the Arabian Sea and the Bay of Bengal.

Inland fisheries. About 11 per cent of the commercial catch of fish worldwide is harvested yearly from ponds, lakes, rivers, streams, and fish farms in inland waters. China and India lead all other countries in the fish catch from inland waters. Both China and India chiefly harvest carp, tilapia, and other plant-eating fish.

Before its breakup, the Soviet Union ranked third in the production of inland-water fish. The Caspian Sea provides much of the inland fish, particularly bream, carp, salmon, and sturgeon. In addition, the rivers that flow into the Caspian yield about 80 per cent of the yearly world total of sturgeon.

The major freshwater fisheries of the United States include the inland waters of the Southern States and the Great Lakes. The inland waters of the South provide buffalo fish, carp, and catfish. The Great Lakes are fished chiefly for alewives, whitefish, smelt, and carp.

Fish farms account for about 10 per cent of the world's annual commercial fish harvest. Each year, they produce about 10 million metric tons of fish, shellfish, and *aquatic plants* (plants that live in water). Fish farming is also called *aquaculture*.

Fish farms range from simple ponds or flooded rice fields to highly engineered hatcheries in which the environment is almost completely controlled. Fish farmers try to eliminate harmful environmental conditions so fish can flourish. They provide fish with proper nutrients and protect them from animals that prey on them. Aquaculture is commonly used to rebuild salmon and trout stocks that have been severely reduced. The chief fish raised on fish farms include carp, catfish, gourami, milkfish, salmon, tilapia, and trout.

China leads all countries in aquaculture production. About 80 per cent of the total output comes from fish raised in ponds. Japan ranks second in aquaculture production. The chief fish and shellfish raised on farms in Japan are oysters, red sea bream, and yellowtail. Japanese fish farms also produce edible seaweed.

How fish are caught

Fishing vessels vary greatly in size and in the number of crew members they carry. Vessels in coastal fishing fleets are generally 8 to 40 metres long. Their crews consist of as many as 20 to 25 people or as few as 1 or 2, depending on the fishing method being used. Coastal vessels can remain at sea for several days or weeks. The catch is kept chilled by ice or refrigeration systems.

Long-range fishing fleets stay at sea for months at a time and travel great distances from their home ports. Many modern fleets, particularly the former Soviet fleets, include *processing-catcher vessels*, as well as processors, refrigerated transporters, and supply ships. Processing-catcher vessels, which measure about 80 metres in length, are used for both catching and processing the fish into various products. Their crews have from 50 to 100 members and usually include women.

Fishing crews use a variety of gear to catch fish. The equipment used depends on the behaviour of the fish being sought and the nature of the fishing grounds. The chief types of gear include (1) nets, (2) hooks, (3) traps, and (4) harpoons.

Fish farmers raise fish in lakes, ponds, reservoirs, and similar bodies of water. The farmers help fish flourish by supplying them with nourishing foods and by protecting them from harmful environmental conditions. The men on the left are harvesting milkfish from a huge fish farm in Laguna de Bay, a lake in the Philippines.

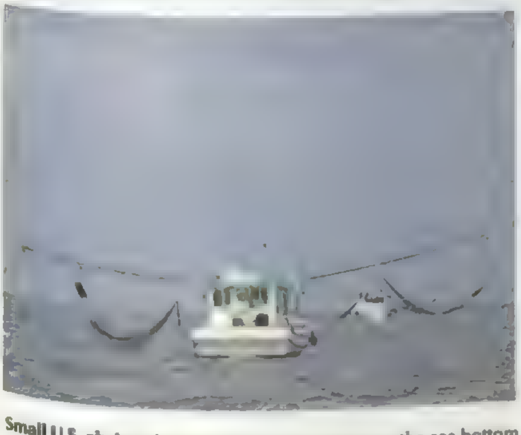
Nets. There are three main types of commercial fishing nets: (1) seines, (2) trawls, and (3) gill nets.

Seines account for more than a third of the world's fish catch. Fishing crews use seines chiefly to catch anchovies, capelin, herring, mackerel, menhaden, sardines, tuna, and other *pelagic* schooling fish. Pelagic fish swim near the surface of the water.

The most widely used seine is the rectangular *purse seine.* Purse seines range from about 200 to 2,000 metres in length. They have floats along the top. Weights and rings are attached along the bottom edge. A rope or cable called a *purse line* runs through the rings.

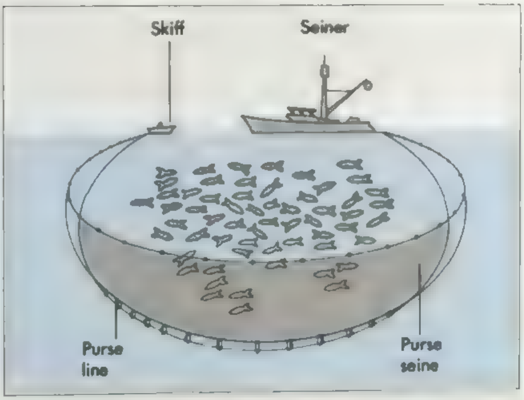
A purse seine is set into the water from a large vessel called a *seiner* with the aid of a small, high-powered boat called a *skiff.* After a school of fish is spotted, the skiff is launched from the seiner with one end of the net attached. The seiner speeds ahead, encircling the school and playing out the net as it goes. The bottom of the seine is then closed off with the purse line, capturing the school. Seiners vary from about 10 to 70 metres in length and carry crews of 12 to 20 people.

A large Japanese ***long-liner,*** *above,* processes fish caught off the Aleutian Islands. Such ships are an important part of many fishing fleets that range far from their home ports.

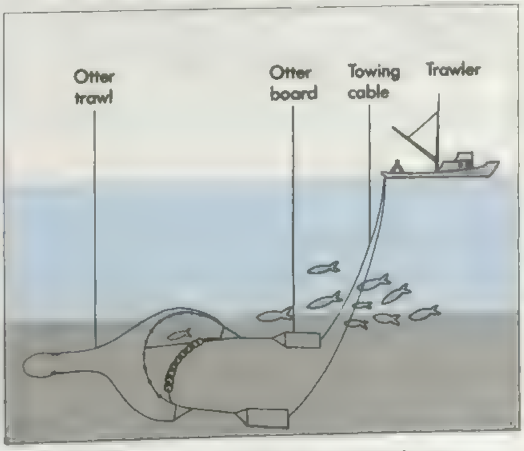


Small U.S. shrimp boats, *above,* drag nets over the sea bottom to harvest shrimp. The catch is quickly frozen or canned on the boats or onshore to prevent it from spoiling.

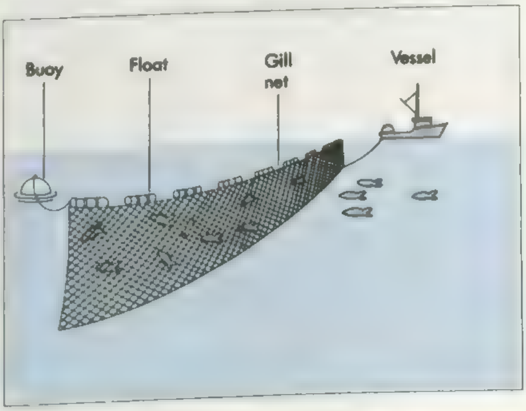
Common types of fishing nets



A purse seine is set from a vessel called a *seiner* by a *skiff* (small boat). Fish are caught by surrounding them with the net and then closing off its bottom with a *purse line* (rope or cable).



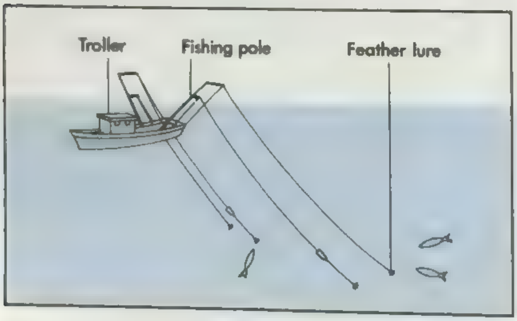
An otter trawl is towed by a vessel called a *trawler* or *stern trawler.* The towing causes two doorlike *otter boards* near the mouth of the net to hold the net open to capture fish.



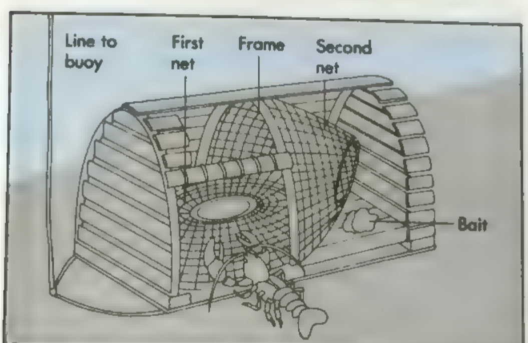
A gill net forms a wall of fine-mesh net that entangles fish when they swim into it. The size of the open spaces of gill nets varies according to the type of fish being sought.

Common methods of hooking and trapping

Long-lining involves using a long *main line* like those coiled inside the buckets. Short *dropper lines* with hooks, shown around the rims of the buckets, are attached to the main line.



Trolling involves towing fishing lines from poles that extend from the sides of a *troller* (trolling vessel). Feather lures are often attached to the ends of the lines to attract fish.



Trapping is often used to catch lobsters and other shellfish. Traps, or pots, are designed so that once a fish or shellfish reaches the bait, it has little chance of escaping.

Trawls are funnel-shaped nets that are closed off at the tail end, where the fish collect, and open at the mouth. The most commonly used trawl is the *otter trawl*. The net has floats along the top edge of the mouth and weights on the bottom edge. The net is attached by two long towing cables to the back of a vessel called a *stern trawler* or *trawler*. A large doorlike *otter board* is attached to each towing cable near the open end of the net. As the trawler tows the net, the water forces the otter boards to spread apart, holding the net open to capture the fish. The mouth of some otter trawls can be spread to a width of almost 40 metres.

Trawls are used to catch cod, flounder, hake, pollock, red snapper, scallops, shrimp, and other fish and shellfish that live on or near the sea floor. Most trawling is done over the continental shelf in waters less than 200 metres deep. However, some stern trawlers fish in waters as deep as 1,000 metres. Trawlers use sonar and other advanced equipment to locate concentrations of fish (see **Sonar**). A small trawler has a four-member crew. Most trawlers more than 45 metres long carry processing equipment, and need larger crews.

Trawling accounts for about a third of the world's fish harvest. The otter trawl is the chief fishing gear of the distant-water fleets of European and Asian nations.

Gill nets are long rectangular nets with floats on top and weights on the bottom. They range from 15 to 400 metres in length. The nets are hung in the water near the surface or close to the sea floor. A gill net is made of thin twine and is nearly invisible in the water. The net is set in the path of migrating fish and forms a wall of webbing that entangles the fish. The open spaces of a gill net allow only a fish's head to go through. Fish try to swim through, and become entangled.

Drift nets are long gill nets of nylon webbing. They measure about 5 kilometres long. A single vessel can set out 8 to 10 drift nets, stretching a total of about 50 kilometres. These nets are allowed to drift and may accidentally entangle dolphins, whales, and even sea birds. In addition, the nets create a hazard to ships, whose propellers can become entangled in the nets.

Many fishing groups and environmental organizations have called for a halt to drift-net fishing. In November 1991, the UN passed a *moratorium* (temporary halt) on drift nets in *international waters* (bodies of water that lie outside the authority of any nation). The moratorium, which took effect on Jan. 1, 1993, banned the use of all drift nets at least $1\frac{1}{2}$ nautical miles (2.8 kilometres) long in international waters. Most nations have complied with the moratorium.

Hooks take advantage of the feeding behaviour of fish. Bait or lures attached to a hook tempt fish to bite the hook. Hooks account for only a small percentage of the world's fish catch. The most common hooking methods used by commercial fishing crews are (1) bait fishing, (2) trolling, and (3) long-lining.

Bait fishing. In bait fishing, after a school of fish is sighted, the crew throws live bait or ground-up fish into the water from the fishing boat. The bait attracts schools of tuna or other species that feed on smaller fish to the surface near the boat. As the fish feed greedily on the bait, the crew uses bare hooks and lines to haul them in. Most bait boats have a walkway around the stern from which a crew of as many as 20 people pull in the fish.

Trolling involves towing as many as six fishing lines from two long poles. One pole extends from each side of the trolling vessel or *troller.* In many cases, metal flashers or feather lures are attached to the lines to attract fish. A large fleet of trollers fishes for albacore and salmon off the western coasts of Canada and the United States. Billfish and tuna are also caught by trolling. Most trollers have crews of only two people.

Long-lining involves using a long *main line* with attached short *dropper lines.* The main line may be stretched across the surface of the water to catch such pelagic fish as billfish, sharks, and tuna, or near the sea floor to catch such bottom fish as cod and halibut. As many as 2,000 dropper lines with baited hooks hang from the main line. Some pelagic lines may be 100 kilometres long. Bottom long-lines are much shorter. A small long-line vessel needs a crew of 3 or 4 persons. Large Japanese tuna vessels carry crews of 20 to 45.

Traps depend on the migratory or feeding habits of fish. Most traps contain bait or lures to attract fish into the devices. Only a small fraction of the worldwide fish harvest is taken by means of traps.

A fish trap has an entry consisting of a funnellike tunnel or ramp. This entry directs fish through a small opening in the side of the trap. Once inside the trap, the fish have little chance of escaping.

Small, baited, boxlike traps are used chiefly to capture shellfish, such as crabs and lobsters. These traps are placed on the bottom of the sea or a lake or stream. Larger, stationary traps are floated near shore in the path of migrating fish. These traps are anchored in place or fastened to wooden pilings driven into the seabed. They are used mainly to catch herring and salmon.

Harpoons are barbed spears connected by a rope to a vessel or large float. They may be shot from a cannon or hurled by a crew member. Harpoons are used mainly to kill whales. For more information on whaling and the use of harpoons, see **Whale** (Modern whaling).

How fish are processed and marketed

Methods of processing. The quality of fish declines rapidly after they die. Bacteria that can cause spoilage immediately begin to attack the fish, and enzymes start to break down the protein in fish tissues. As a result, a number of processing methods have been developed over the years to keep fish from spoiling.

Drying, salt curing, and smoking have been used to process fish for thousands of years. All three methods reduce the moisture content of fish and thus slow the growth of bacteria and the breakdown of protein.

Drying fish in the open air for six weeks or more removes most of the water from them. Drying is generally used along with salt curing or smoking.

In salt curing, processors first cut open the fish and remove the head and backbone. They then cover the fish with salt, which draws out the moisture and produces a salty solution called *brine.* Next, the fish are *dry-salted* or *pickled.* In dry-salting, the brine is drained off and the fish are hung up to dry. In pickling, the fish are stored in the brine.

Processing fish aboard ship helps prevent them from spoiling. The man on the left is cleaning and cutting up fish on a Japanese factory ship shortly after they were caught. The fish are then quickly frozen and stored in freezer compartments, *right.*

Onshore processing of fish is done in fishing ports. These workers at a plant in Prince Rupert, Canada, are preparing deboned, meal-sized portions of fish for shipment to markets.

To smoke fish, processors first cut up the fish and soak them in brine. They then place the fish in a large oven, where smoke and heat from smouldering wood chips dries the fish. Processors use this method chiefly to improve the flavour of fish.

Canning involves sealing cut up fish in metal or glass containers and then cooking the contents under pressure. The high temperature and pressure kill bacteria and halt protein breakdown.

Freezing also prevents the growth of bacteria and protein breakdown. The quickly frozen fish are packaged in airtight wrappers or covered with a thin layer of ice. They are stored at about −30 °C or lower. Much of the catch of such fish as cod and flounder is *filleted* (deboned) and frozen. Often, the individual fillets are frozen together in large blocks of fish. These blocks may then be made into fish sticks or fingers, and meal-sized portions of breaded fish. Fish may be minced before freezing to make *surimi,* a fish paste with a high protein content. In Japan, surimi is used mainly to make fish cakes. Surimi is used in other countries to make imitation shellfish products.

Other processing methods are used to produce meal and oil from fish. These industrial products are made from such species as anchovies, capelin, herring, menhaden, and sardines. To produce fish meal and fish oil, processors first cook the fish with steam. They then squeeze out most of the water and oil. The remaining solid material is dried and ground into meal. Fish oil is obtained by separating the oil from the water in a whirling device called a *centrifuge.*

Fish meal is added to livestock feed and dry pet food. It is also fed to trout and salmon raised in hatcheries. Manufacturers use fish oil to make a number of products, including glue, paint, lubricants, and ink.

Marketing. Fresh fish may be sold daily in fishing ports located near fishing areas. However, fish and fish products to be sold in distant markets must first be processed to prevent spoilage.

Most fish processors operate in fishing ports. Many fishing crews sell their catches to processors at auctions after fishing trips. The price a catch commands depends on the supply of fish at the market and the demand for it. A fishing crew does not know in advance what a harvest will earn—if it is sold at all. The uncertainty of the auction market has led some fishing crews to form *marketing cooperatives.* Cooperatives enable their members to know, before they leave port, how much fish to catch and how much the harvest will earn. Processors place orders with the cooperative for a specific quantity of fish before a fishing trip. At the same time, both sides agree on the price to be paid for the catch.

Processors sell most of their fish products to fish brokers in large cities. The brokers, in turn, sell the products to restaurants and food stores.

Fishery conservation

Countless fish die of natural causes or are eaten by animals that prey on them. Nevertheless, a rich fishery will continue to support good catches as long as the stock can produce large numbers of young annually. Problems arise chiefly as a result of overfishing and the polluting of the waters in which the fish live. Fishery conservation seeks to control the human activities that can severely reduce a fish stock.

Government regulation. Most major fishing nations have laws to conserve and protect their fish resources. Almost all nations that border the sea have established authority over fishery conservation zones extending 200 nautical miles (370 kilometres) from their shores. These zones are intended to protect the nations' coastal fishing industries by controlling the harvest of fleets of other countries. They also enable the nations to pass conservation laws affecting the areas.

Some regulations set quotas that limit the total catch of certain species in a fishery and in a few cases limit the number of fishing vessels permitted in an area. Other regulations restrict the areas and the time of year in which crews may fish. The size and type of fishing gear that may be used in a fishery are also regulated.

Water pollution controls also aid in fishery conservation. Such controls limit the amount of harmful materials that may be released into inland and coastal waters. These materials can kill fish or the plants and animals on which fish feed.

International commissions and treaties. Through the years, fishing nations have agreed to work together in managing fishery resources in international waters. A number of commissions have been established to protect a particular species of fish or all species in a given area.

Most international commissions devoted to fishery conservation operate in a similar manner. Scientists from the member nations or from the organization itself gather statistics on the size of the catch and conduct other research regarding a particular fishery or species

of fish. The commissions meet annually to review these studies and to recommend ways of managing fishery resources. Each member nation must then pass and enforce laws based on the recommendations.

Many nations also make *bilateral treaties* to manage fishery resources in international waters. Under such treaties, two nations agree to meet periodically to exchange information on fisheries of interest to both countries and to discuss conservation measures.

Scientific research involves many activities to improve fish harvests. Researchers determine the maximum number of fish that can be harvested annually without severely damaging the stock. Researchers often rely on records of the harvest in a fishery to check changes in the abundance of stocks from year to year. By analysing these records, they can judge whether fishing should be increased or decreased.

Scientists study the effects of the environment on changes in fish abundance and the effects of fishing on other species. Most fish feed on other fish. Dolphins, seals, and marine birds also prey on fish. Overfishing of prey species, such as anchovies, herring, and sardines, reduces the food supply of predator species. However, overfishing of predator species, such as cod, salmon, and tuna, increases the supply of prey species.

Some researchers work to increase the rates of survival and growth of fish. Such research especially helps fish farmers. Commercially raised fish have greatly increased fish resources, chiefly in Asia and Europe. In addition, some researchers are studying unharvested types of fish to develop new products and markets. Such efforts seek both to increase the world's food supply and to promote fish conservation. Through the development of new fish resources, the world's total catch can remain constant or even be increased—without overfishing individual stocks.

Related articles in *World Book*. Many country articles have a section on fishing industry. See, for example, **Japan** (Fishing industry). See also:

Some food fishes

Anchovy	Grouper	Pompano	Sprat
Bass	Haddock	Rosefish	Sturgeon
Carp	Halibut	Salmon	Swordfish
Catfish	Herring	Sardine	Trout
Cod	Mackerel	Shad	Tuna
Dogfish	Menhaden	Smelt	Turbot
Drum	Mullet	Snapper	Weakfish
Flounder	Perch	Sole	Whitefish

Other seafoods

Abalone	Crayfish	Oyster	Shrimp
Clam	Lobster	Scallop	Squid
Crab	Mussel		

Other related articles

Aquaculture	Food preservation	Net
Cormorant	Grand Banks	Pearl
Fish	Gulf Stream	Sponge
Fishing	Krill	Whale

Outline

I. Where fish are caught
- A. Sea fisheries
- B. Inland fisheries
- C. Fish farms

II. How fish are caught
- A. Nets
- B. Hooks
- C. Traps
- D. Harpoons

III. How fish are processed and marketed
- A. Methods of processing
- B. Marketing

IV. Fishery conservation
- A. Government regulation
- B. International commissions and treaties
- C. Scientific research

Questions

What types of fisheries provide most of the world's commercial fish catch?
Why are fish a valuable food?
What is upwelling? How does it help the fish population in an area grow?
How does the marketing cooperative method of selling a fish catch differ from the auction method?
What are fish farms?
Which are the world's leading fishing countries?
What is a purse seine? How does it work?
How may overfishing of one species of fish affect the populations of other species?
What are fish meal and fish oil? What are they used for?
How do fishery conservation zones aid in fish conservation?

Fishing laws. See **Fishing industry** (Fishery conservation).

Fishworm. See **Earthworm.**

Fisk, Sir Ernest (1896-1965), a radio engineer, received the first direct wireless message between England and Australia in 1918. In 1924, he received the first voice message from England. He pioneered Australia's beam wireless service. Ernest Thomas Fisk was born at Sunbury-on-Thames, in England. He became managing director of Amalgamated Wireless Australasia (A.W.A.) in 1917 and was chairman of the board from 1932 to 1944. He was knighted in 1937.

Fission, in physics, is the splitting of the nucleus of an atom into two nearly equal parts. This process occurs most readily in such heavy elements as uranium and plutonium. Fission can take place naturally or it can be produced artificially by striking a fissionable nucleus with a neutron or some other nuclear particle.

When a nucleus splits into two *fission fragments,* a large amount of energy is released. This energy comes from a decrease in the mass of the original fissionable nucleus. It can be calculated using Einstein's equation: $E = mc^2$ (energy = mass $\times$ the speed of light squared). The fission of 0.45 kilogram of uranium releases as much energy as the burning of 1,000 metric tons of coal.

A fissioning nucleus also releases several neutrons. These free neutrons may strike other nuclei and cause them to fission. A continuous series of such fissions, called a *chain reaction,* produces the energy in atomic bombs and nuclear reactors.

See also **Nuclear energy; Plutonium; Uranium.**

Fistula is a deep, sometimes twisting, passage developing abnormally in the body. It may lead from the deep tissues to the outside through an opening in the skin. Or it may form an abnormal connection between two deep organs. It may connect a deep organ, such as the stomach, with the surface. Sometimes a fistula drains pus from a deep abscess. Or it may connect two hollow organs such as the bladder and rectum. Fistulas may be caused by wounds or disease. They can be corrected by surgery.

Fitch, John (1743-1798), was an American inventor and metal craftsman. He built and operated a mechanically successful steamboat 20 years before Robert Fulton's *Clermont* made its first trip on the Hudson River. Fitch

had constant trouble with his financial affairs, and did not succeed in attracting enough public support to make his boats profitable.

In 1787, he demonstrated the first workable steamboat in the United States. The boat sailed on the Delaware River. It was propelled by six paddles on each side but was driven by a steam engine. Fitch launched an 18-metre boat in 1788. He launched another boat in 1790. It operated a regular passenger service from Philadelphia to Burlington, New Jersey, but there was not enough demand for passage to make it pay. Fitch's other attempts in this field were unsuccessful.

Fitch was born in Windsor Township, Connecticut, U.S.A. He became a successful brassworker and silversmith in Trenton, New Jersey. The business was wiped out by the American Revolution (1775-1783), in which Fitch served as a lieutenant. He turned his attention to the construction of a steamboat in 1785.

See also **Fulton, Robert; Ship** (History: The first steamboats); **Steamboat.**

Fitt, Gerard (1926-), Lord Fitt of Bell's Hill, was an independent Socialist politician. He represented the Northern Ireland constituency of Belfast West in the British House of Commons from 1966 to 1983. He supported the republican view of the Northern Ireland issue but strongly opposed the Provisional Irish Republican Army's campaign of terrorist violence.

Fitt was a founder of the Social Democratic and Labour Party (SDLP) and he led it from 1970 to 1979. In 1979, he resigned the party leadership and became a Socialist MP. He lost his seat at Westminster in 1983, and was later created a life peer.

Fitt was educated at the Christian Brothers School, Belfast. From 1941 to 1953, he was a merchant seaman. He became a member of the Northern Ireland (Stormont) Parliament in 1962 and of the Westminster Parliament in 1966. After the Stormont Parliament was ended in 1972, Fitt served in the Northern Ireland Assembly (1973-1975) and the Constitutional Convention (1975-1976).

Fitzalan, Walter (ancestor of the Royal House of Stuart). See **Scotland, History of** (Independent Scotland).

FitzGerald, Edward (1809-1883), was an English writer famous for his translation of the *Rubaiyat,* a long poetic work by the Persian poet of the 1200's, Omar Khayyam. The poem's melancholy theme of "drink and be merry for tomorrow we die" described the mood of many people in England during the late 1800's.

FitzGerald's translation was first published anonymously in 1859. The translation was ignored until 1860, when the famous English poet Dante Gabriel Rossetti and his circle discovered the work and helped popularize it. FitzGerald prepared three revised editions, which were published in 1868, 1872, and 1879. In addition to the *Rubaiyat,* FitzGerald was known for his translations of Greek and Spanish literature and for his charming letters. FitzGerald was born in Suffolk, England.

See also **Rubaiyat.**

Fitzgerald, Ella (1918-), ranks among the best and most popular jazz singers of all time. She is known for her pure and personal tone, remarkable vocal control, ability to improvise, and flawless intonation and phrasing as an interpreter of ballads. She also became famous for her ability to improvise through *scat singing.* In this style, rhythmic wordless syllables are sung instead of lyrics.

Ella Fitzgerald

Ella Fitzgerald was born in Newport News, Virginia, U.S.A. She won several amateur contests as a singer before joining Chick Webb's band in 1935. She recorded her first hit, "A Tisket A Tasket," with Webb's band in 1938. Webb died in 1939, and she took over leadership of the band for two years. In 1941, Fitzgerald began to work as a solo performer and with vocal groups. She gained world fame while working with the "Jazz at the Philharmonic" touring group of musicians and singers beginning in 1948.

Fitzgerald, F. Scott (1896-1940), was the leading writer of America's *Jazz Age,* the *Roaring Twenties,* and one of its glittering heroes. The chief quality of Fitzgerald's talent was his ability to be both a leading participant in the high life he described, and a detached observer of it. Few readers saw the serious side of Fitzgerald, and he was not generally recognized as a gifted writer during his lifetime. While he lived, most readers considered his stories a chronicle and even a celebration of moral decline. Later readers realized that Fitzgerald's works have a deeper moral theme.

Francis Scott Key Fitzgerald was born in St. Paul, Minnesota, U.S.A., on Sept. 24, 1896. He attended Princeton University, where he wrote amateur musical comedies. He left Princeton in 1917 without a degree. Years after leaving Princeton, Fitzgerald remarked that perhaps he should have continued writing musicals, but he said, "I am too much a moralist at heart, and really want to preach at people in some acceptable form, rather than entertain them."

F. Scott Fitzgerald

Fitzgerald won fame and fortune for his first novel, *This Side of Paradise* (1920). It is an immature work but was the first novel to anticipate the pleasure-seeking generation of the Roaring Twenties. A similar novel, *The Beautiful and Damned* (1921), and two collections of short stories, *Flappers and Philosophers* (1920) and *Tales of the Jazz Age* (1922), increased his popularity.

The Great Gatsby (1925) was less popular than Fitzgerald's early works, but it was his masterpiece and the first of three successive novels that give him lasting literary importance. The novel centres on Jay Gatsby, a wealthy bootlegger. *The Great Gatsby* presents a penetrating criticism of the moral emptiness of wealthy society in the United States during the 1920's.

Fitzgerald's next novel, *Tender Is the Night* (1934, revised edition by Malcolm Cowley, 1951), is a beautifully written account of the general decline of a few glamor-

ous Americans in Europe. The book failed because readers during the Great Depression of the 1930's were not interested in Jazz Age "parties." Fitzgerald died before he completed *The Last Tycoon* (1941), a novel about Hollywood life.

Critics generally agree that Fitzgerald's early success damaged his personal life and marred his literary production. This success led to extravagant living and a need for a large income. It probably contributed to Fitzgerald's alcoholism and the mental breakdown of his wife Zelda. The success also probably led to his physical and spiritual collapse, which he described frankly in the long essay *The Crack-Up* (1936). Fitzgerald spent his last years as a scriptwriter in Hollywood. A few years after his death, his books won him the recognition he had desired while alive.

See also **American literature** (The "Lost Generation"); **Roaring Twenties.**

FitzGerald, Garret (1926-   ), was *Taoiseach* (prime minister) of the Republic of Ireland from December 1982 until March 1987, when he lost an election. Soon after the election, he resigned as leader of his party, *Fine Gael.* He had previously been Taoiseach from July 1981 to February 1982. Both of his governments were coalitions of his own party with the Labour Party.

Garret Michael Desmond FitzGerald was born in Dublin and educated at Belvedere College and University College, Dublin. He was called to the Irish Bar in 1947, but took up his main career first in transport management and later in economics and journalism. In 1959, he became a lecturer in political economy at University College, Dublin.

From 1965 to 1969, FitzGerald served in *Seanad Éireann* (the Irish Senate). He entered *Dáil Éireann* (the Irish House of Representatives) and became vice president of Fine Gael in 1969. He was Minister for Foreign Affairs from 1973 until 1977. He became leader of Fine Gael in 1977, following the resignation of his predecessor, Liam Cosgrave.

Fitzgerald, R. D. (1902-1987), a leading Australian poet, wrote poetry concerned mainly with the nature of human existence. His prize-winning poem, *Essay on Memory,* deals with the influence of past experience on the present. His books of poetry include *Between Two Tides, Moonlight Acre, This Night's Orbit, Southmost Twelve,* and *Forty Years Poems.* Robert David Fitzgerald was born in Sydney.

Fitzroy, Robert (1805-1865), was a British naval officer, meteorologist, and oceanographer. He was captain of the *Beagle,* the ship that carried Charles Darwin around the world (see **Darwin, Charles**). Fitzroy surveyed the coast of South America and collected surveys of 82 coasts and 80 harbours. In 1855, he set up a weather-forecasting service for the government. He was born in the county of Suffolk, in England.

Fitzsimmons, Bob (1863-1917), held the world's heavyweight boxing championship from 1897 to 1899. Fitzsimmons also held the world's middleweight title from 1891 until he won the heavyweight championship in 1897. He was the light-heavyweight champion of the world from 1903 until 1905. Fitzsimmons gained the heavyweight title by knocking out James J. Corbett in 14 rounds. He is credited with originating the solar plexus punch in this fight (see **Solar plexus**). Fitzsimmons lost the heavyweight title to James J. Jeffries on a knockout in the 11th round.

Robert James Fitzsimmons was born in Helston, England. He grew up in New Zealand and did his early fighting in Australia. Fitzsimmons moved to the United States in 1890.

Five Books of Moses. See **Pentateuch.**

Five-finger. See **Cinquefoil.**

Five Members, The. See **Civil War, English.**

Five Towns is an area in the county of Staffordshire, England, that forms the setting for many of the novels of Arnold Bennett (see **Bennett, Arnold**). The five towns were Burslem, Hanley, Longton, Stoke-on-Trent, and Tunstall. The towns are in an area popularly known as *the Potteries* (see **Potteries**). In his books, Bennett calls the towns Bursley, Hambridge, Longshaw, Knype, and Turnhill, respectively. The five towns, together with Fenton, amalgamated in 1910 to form the county borough, and later the city, of Stoke-on-Trent.

Five-year plan is a programme to increase the economic and social development of a country over a five-year period. Many countries have had such plans drawn up by their governments. Examples include China and India. The plan details how much the government intends to spend on the various parts of the economy, particularly in those areas that will help the country to industrialize and develop. For example, a plan may include ideas for new roads, railways, airports, and seaports and for spending on such items as schools, universities, and hospitals. Individual countries' plans vary in scope and detail. Many are flexible and will be adjusted during the five-year period to reflect changes in international economic conditions.

Fives is a simple ball game for two players. Using a gloved hand, each player takes turns striking a small rubber ball and making it bounce against a wall. The ball must hit the wall above a line and then bounce within the court. Players must return the ball to the wall by hitting it either in the air or after the first bounce. Anyone can make a fives court by marking a line 762 millimetres high along a wall and marking a court about 5 metres wide and 9 metres long. More complicated versions of fives are played at the independent English schools of Eton, Rugby, and Winchester. See also **Handball.**

Fixed star is an expression often used in referring to the stars, because their places in the sky relative to one another do not seem to change. Actually, however, the stars are moving in many directions, and the pattern of the heavens is very slowly changing.

But the changes are scarcely noticeable within a person's lifetime, because the stars are so far away and the distances between them are so great. Even Barnard's star, the one believed to move the fastest, changes position by a distance equal only to the moon's diameter in 200 years. Compared to the planets, which can be seen constantly shifting their positions in the sky, the starry background seems "fixed."

Astronomers use photography to study the motions of all of the bright stars and many of the faint ones. In photographs taken at different times many years apart, they compare the positions of the stars and note how the stars have changed. They can then tell how the *constellations* (groups of stars) will appear in the future.

Fjord. See **Fiord.**

National flags are perhaps the most important group of flags. A nation's flag stands for its land, its people, its government, and its ideals. When the flags of several countries are displayed, they are flown at the same height from separate staffs of equal size.

Flag

Flag. A flag may represent a nation, person, or organization; it may symbolize a belief or idea; or it may transmit information. The most important group of flags are probably national flags. A nation's flag is a stirring sight as it flies in the wind. Its bright colours and striking design stand for the country's land, its people, its government, and its ideals. A country's flag can stir people to joy, to courage, and to sacrifice. Special rules for display and care have grown up around people's wish to honour their nation's flag.

Nations use many kinds of flags besides national flags. Some countries fly a special *state* flag over embassies and other government buildings at home and abroad. Presidents, kings, queens, and other government leaders may have their own flags. States, provinces, and cities are represented by flags. Some flags stand for international organizations, such as the United Nations (UN) and the Red Cross. Such regional groups as the Organization of African Unity and the European Community have flags. Other organizational flags include those of youth groups, like the Boy Scouts and hobby societies. Many religions and churches have their own flags. Flags may also be used to send messages.

Such peoples as the Egyptians, Persians, Greeks, and Romans carried flaglike objects thousands of years ago. These "flags," called *standards,* consisted of symbols attached to the tops of poles. The symbols, which might include cloth, wood, metal, and other materials, usually stood for the people's gods or rulers. Soldiers carried the symbols into battle, hoping that their gods would help them win.

Flags became important during battles for a variety of reasons. Soldiers of the Egyptians and other ancient peoples sometimes tied streamers to the poles they carried. The streamers—like later cloth flags—showed which way the wind blew, and helped soldiers see the

A national flag gains its power as a symbol in part from the role it plays in the nation's history. A crowd bearing a banner with the colours of the Russian flag, *left,* celebrates the fall of Communism in the Soviet Union in late 1991. Soon afterward, the Soviet Union was dissolved and Russia became independent.

direction to aim their arrows. Flags stood for each side in a battle, and generals watched them to see where their soldiers were. Defending the flag was regarded as the chief duty of a soldier. If the soldier carrying the flag was killed or wounded, others would "rally round the flag" to prevent the enemy from capturing it. If the flag was captured, many soldiers would give up the fight.

The symbols used in flags may go back thousands of years. The Shield of David, an ancient symbol of the Jews popularly known as the "Star of David," appears on the flag of Israel. The cross, a symbol of Christianity, is displayed on the flags of many Christian nations. The crescent and star in the flags of many Muslim countries are symbols of peace and life. Stars on flags often stand for unity. The number of stars on a nation's flag may show how many states are united in the country.

Most national flags use one or more of only seven basic colours. These colours are red, white, blue, green, yellow, black, and orange. The colours were all used in *heraldry,* a system of designs that grew up during the Middle Ages (see **Heraldry**). Designs follow rules of heraldry. Such designs include a strip of white or yellow separating two colours. The Mexican flag, with white between red and green bands, follows this rule.

Popular stories often explain why flags have certain colours and designs. For example, the Austrian flag supposedly dates from an event in 1191, during the Third Crusade, a military expedition attempting to regain the Holy Land from the Muslims. When Duke Leopold V removed his blood-stained cloak after a battle, he found that his belt had kept a band of the cloth white. From then on, he used a red flag with a white stripe across it. Austria adopted this design in 1919. Denmark's national flag—a white cross on red—is said to have originated more than 750 years ago. According to tradition, King Valdemar the Victorious of Denmark saw a white cross in the red sky just before he won a battle in 1219.

Nations that have a common history may use the same colours in their flags. Blue and white appear in the flags of Costa Rica, El Salvador, Guatemala, Honduras, and Nicaragua. These nations were once joined together in the United Provinces of Central America, which had a blue-and-white flag. Four colours—black, green, red, and white—stand for Arab unity. These colours appear in the flags of Egypt, Iraq, Jordan, Kuwait, Sudan, Syria, the United Arab Emirates, and Yemen.

The study of the history and symbolism of flags is called *vexillology.* The name comes from the Latin word *vexillum,* meaning a square flag or banner. Soldiers of ancient Rome carried a square military flag that hung from a crossbar fastened to a staff.

Interesting facts about flags

The first "flags" consisted of symbols attached to the tops of poles. Such flaglike objects appear in Egyptian art of the mid-3000's B.C.

Cloth flags were probably first used in China about 3000 B.C. These flags were made of silk.

Knights in the Middle Ages carried square flags with a streamer called a *schwenkel* attached. A knight's promotion to higher rank was symbolized by having the schwenkel cut off. The resulting flag was called a *banner,* and the knight became a *knight-banneret.*

National flags are among the most recent kinds of flags. They first came into use during the 1700's in Europe and North America. Until then, most flags stood for the personal authority of rulers.

Flags at sea. Before the days of radio, a complicated system of flag design and display grew up around the need for communication at sea. Flag codes enabled the sending of messages between ships or from a ship to shore. A ship would salute another vessel by *dipping,* or lowering, its flag. Such salutes played a major role in international diplomacy.

Flag colours. Most national flags use one or more of only seven basic colours. These colours are red, white, blue, green, yellow, black, and orange.

Flag symbols often reflect historical events. The cross that appears in many European flags originated in the flags carried by Crusaders to the Holy Land. Some flags used in Arab nations show the eagle of Saladin, a Muslim warrior who fought the Crusaders in the 1100's.

Burning is considered the most dignified way to destroy a flag that is no longer fit for display. But burning a usable flag often signifies political protest.

Flags of Africa

The ratio that appears below each flag represents the relation between the *hoist* (vertical width) and the *fly* (horizontal length). For example, Algeria's flag is two units vertically for every three units horizontally.


2:3

Algeria

Angola


2:3

Benin


2:3

Botswana


2:3

Burkina Faso

Burundi


2:3

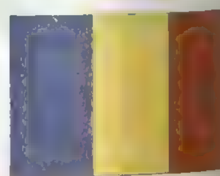
Cameroon


10:17

Cape Verde


3:5

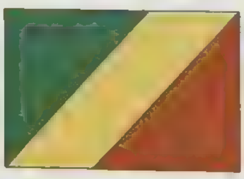
Central African Republic


2:

Chad


3:5

Comoros


2:3

Congo

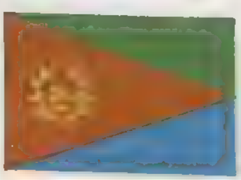

21:38

Djibouti

Egypt


2:3

Equatorial Guinea

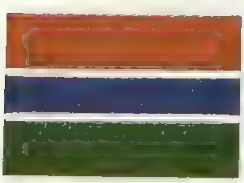

2:3

Eritrea


1:2

Ethiopia

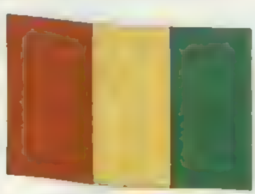
Gabon


2:3

Gambia


2:3

Ghana

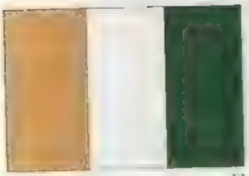

2:3

Guinea

Guinea-Bissau

Flags of Africa

continued



2:3

Ivory Coast

2:3

Kenya

2:3

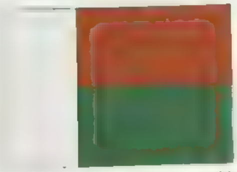
Lesotho

10:19

Liberia

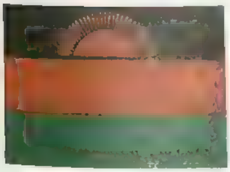
1:2

Libya



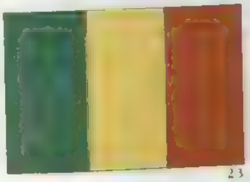
2:3

Madagascar



2:3

Malawi



2:3

Mali

2:3

Mauritania

2:3

Mauritius

2:3

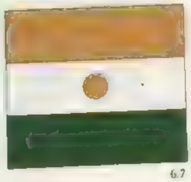
Morocco

2:3

Mozambique

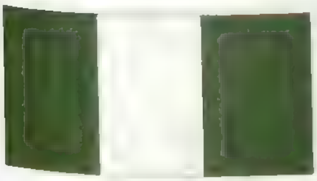
2:3

Namibia



6:7

Niger



1:2

Nigeria

2:3

Rwanda

1:2

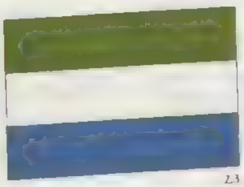
São Tomé and Príncipe

2:3

Senegal

1:2

Seychelles



2:3

Sierra Leone

2:3

Somalia

Flags of Africa

continued

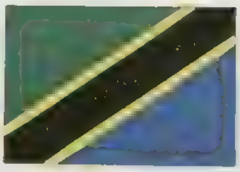

2:3

South Africa

Sudan


2:3

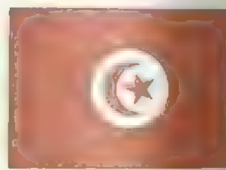
Swaziland


2:3

Tanzania


3:5

Togo



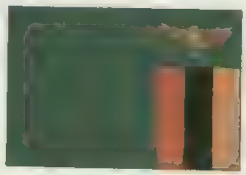
Tunisia


2:3

Uganda


2:3

Zaire


2:3

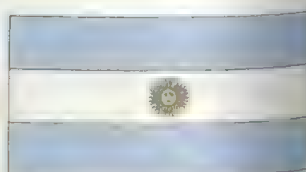
Zambia

Zimbabwe

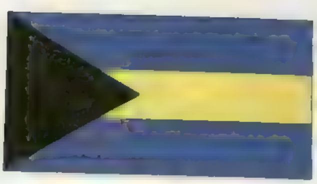
Flags of the Americas


2:3

Antigua and Barbuda


1:2

Argentina


1:2

Bahamas

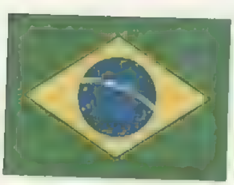

2:3

Barbados


2:3

Belize

Bolivia


7:10

Brazil


1:2

Canada


2:3

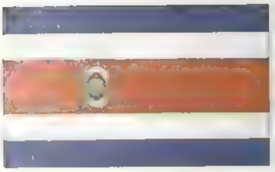
Chile


2:3

Colombia

Flags of the Americas

continued


3:5

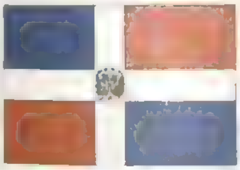
Costa Rica


1:2

Cuba


1:2

Dominica


2:3

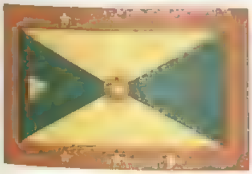
Dominican Republic


1:2

Ecuador


189:335

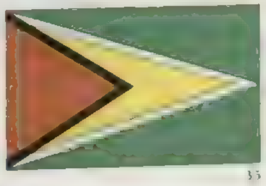
El Salvador


3:5

Grenada


5:8

Guatemala


3:5

Guyana


3:5

Haiti


1:2

Honduras


1:2

Jamaica


4:7

Mexico


3:5

Nicaragua


2:3

Panama


1:2

Paraguay


2:3

Peru


2:3

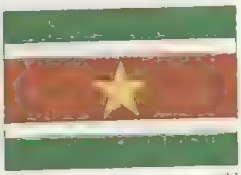
St. Christopher and Nevis


1:2

St. Lucia


2:3

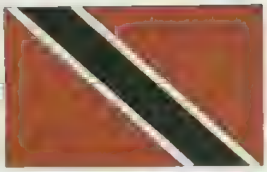
St. Vincent and the Grenadines


2:3

Suriname

Flags of the Americas

continued



3:5

Trinidad and Tobago

United States

2:3

Uruguay

2:3

Venezuela

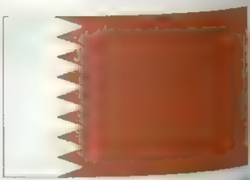
Flags of Asia and the Pacific

Afghanistan 1:2

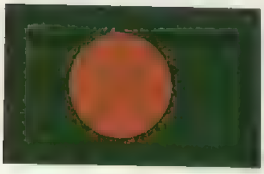
Armenia

Australia 1:2

Azerbaijan 1:2

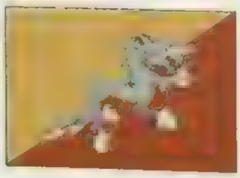


Bahrain



3:5

Bangladesh



2:3

Bhutan

Brunei

5:9

Burma

3:5

Cambodia

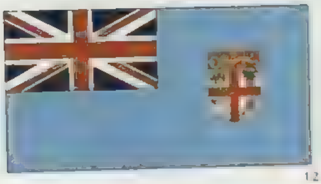
2:3

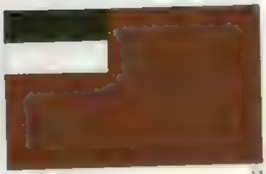
China

Cyprus

Flags of Asia and the Pacific

continued


1:2
Fiji


3:5
Georgia

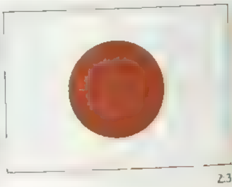

2:3
India


2:3
Indonesia


1:2
Iran

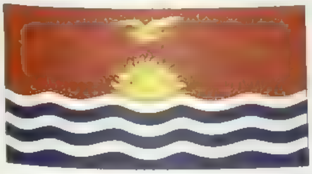

2:3
Iraq


8:11
Israel

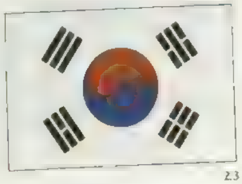

2:3
Japan

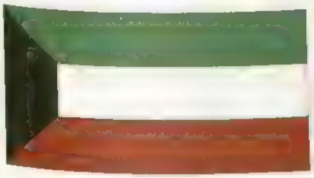

1:2
Jordan


1:2
Kazakhstan

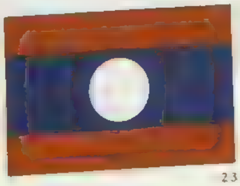

1:2
Kiribati


1:2
Korea (North)

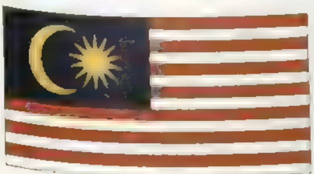

2:3
Korea (South)

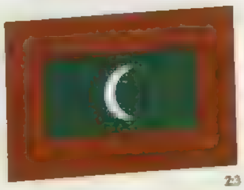

1:2
Kuwait

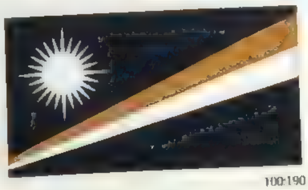

3:5
Kyrgyzstan


2:3
Laos


2:3
Lebanon


1:2
Malaysia


2:3
Maldives

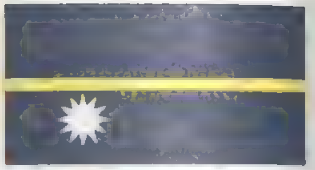

100:190
Marshall Islands

Flags of Asia and the Pacific

continued


10:19
Micronesia


1:2
Mongolia


Nauru

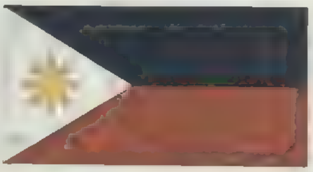

4:3
Nepal


1:2
New Zealand


2:3
Oman


2:3
Pakistan


3:4
Papua New Guinea


1:2
Philippines


11:28
Qatar

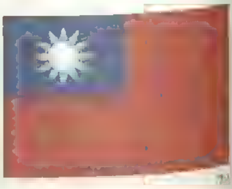

2:3
Saudi Arabia

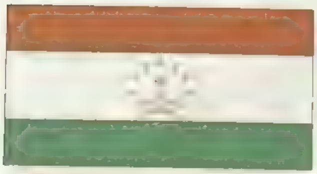

2:3
Singapore


1:2
Solomon Islands

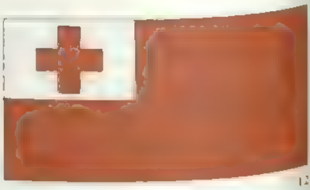

1:2
Sri Lanka


2:3
Syria


2:3
Taiwan


1:2
Tajikistan


2:3
Thailand


1:2
Tonga

Flags of Asia and the Pacific

continued


2:3

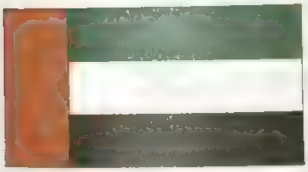
Turkey


1:2

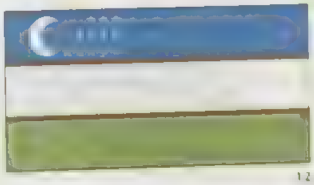
Turkmenistan


1:2

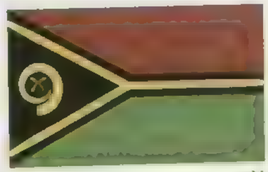
Tuvalu


1:2

United Arab Emirates


1:2

Uzbekistan


3:5

Vanuatu


2:3

Vietnam


1:2

Western Samoa

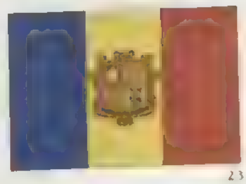

2:3

Yemen

Flags of Europe


5:7

Albania


2:3

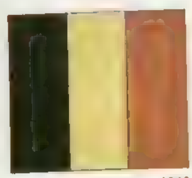
Andorra


2:3

Austria


1:2

Belarus


13:15

Belgium


1:2

Bosnia-Herzegovina


3:5

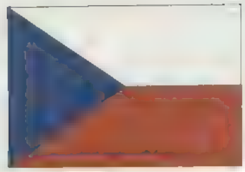
Bulgaria


1:2

Croatia

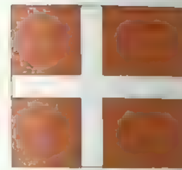
Flags of Europe

continued

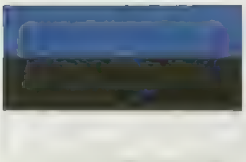


2:3

Czech Republic



Denmark

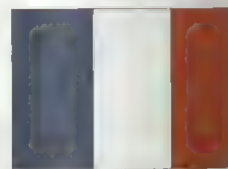


7:11

Estonia

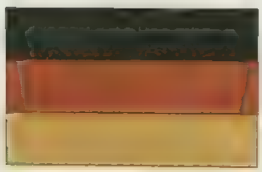
11:18

Finland



2:3

France



3:5

Germany

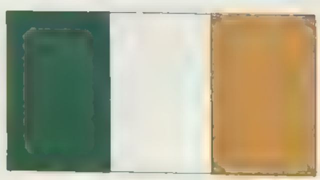
2:3

Greece

Hungary

18:25

Iceland

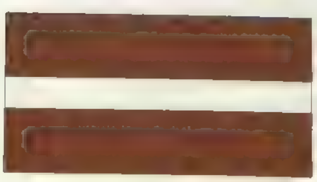


1:2

Ireland

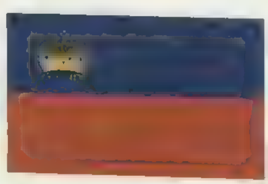
2:3

Italy



1:2

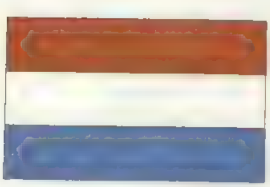
Latvia



3:5

Liechtenstein

Lithuania

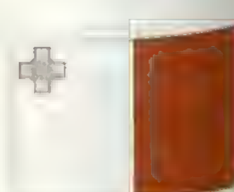


3:5

Luxembourg

1:2

Macedonia



Malta

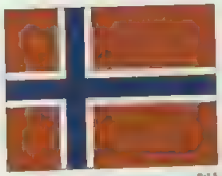
Flags of Europe

continued

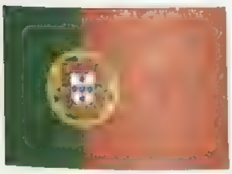

1:2
Moldova

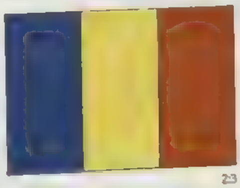

4:5
Monaco

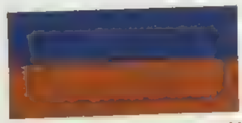

2:3
Netherlands


8:11
Norway


5:8
Poland


2:3
Portugal


2:3
Romania

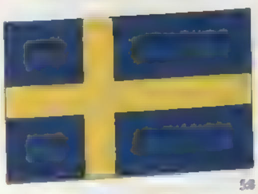

2:3
Russia


3:4
San Marino


2:3
Slovakia


1:2
Slovenia


2:3
Spain

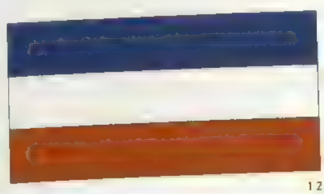

5:8
Sweden


1:1
Switzerland


2:3
Ukraine


1:2
United Kingdom


1:1
Vatican City


1:2
Yugoslavia

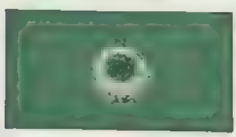
Flags of world organizations

United Nations

North Atlantic Treaty Organization (NATO)

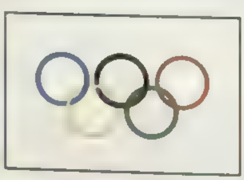
Organization of African Unity (OAU)

European Union and Council of Europe



Arab League

Organization of American States



International Olympic Committee

Red Cross

Red Crescent

Red Shield of David

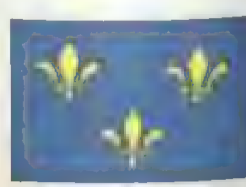
Flags of relief organizations. The Red Cross flag is flown in most countries. The Red Crescent flag is flown in Muslim countries and the Red Shield of David flag in Israel.

Historical flags of the world

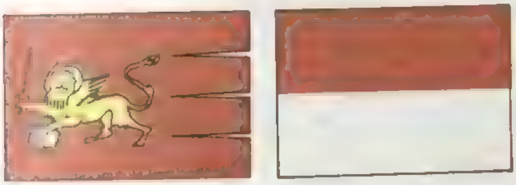
The earliest flags, or *standards,* consisted of symbols attached to poles. Egyptian soldiers of the 3000's B.C. carried standards like the one on the left. The first cloth flags were used in China about the same time. One such flag is shown below.

Roman flags included the *vexillum, left,* a cavalry battle standard. On right is the *labarum* (imperial standard) of Constantine the Great, who adopted Christianity in the A.D. 300's. The letters *XP* on the staff mean Christ.

Religious flags. The Shiite Muslim flag, *left,* shows the sword of Ali, the first leader of the Shiah sect of Islam. The crusader's flag, *right,* was used in the 1100's by Christians seeking to conquer the Holy Land.



English and French flags. King Richard I of England adopted the three lions, *left,* in 1198. This French Royal Banner, *right,* was used from the late 1300's to the 1600's.

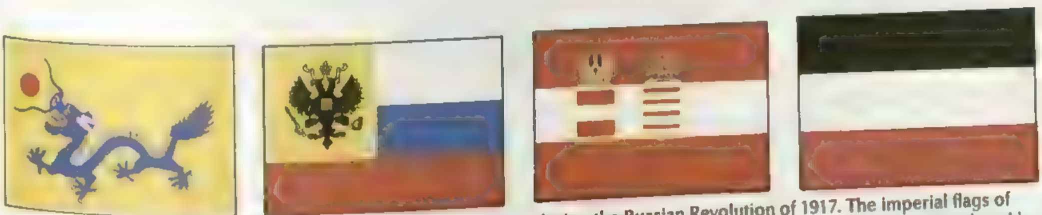


Traders' flags. Ships from Venice flew the symbol of Saint Mark, the city's patron, beginning in the 1300's, *left.* The flag of the Hanseatic League, *right,* dates to about the same time.

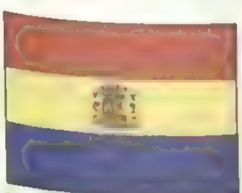
Holy Roman Empire flag flew in what is now Germany from the 1200's until 1806.

Crosses in the British flag. The British Union Flag, *left,* combines symbols of England, Scotland, and Ireland. The cross of St. George, *above,* was a national symbol of England as early as the 1200's. The cross of St. Andrew, *above,* had long been a symbol of Scotland, and the cross of St. Patrick, *right,* of Ireland. Britain first flew this Union Flag in 1801.

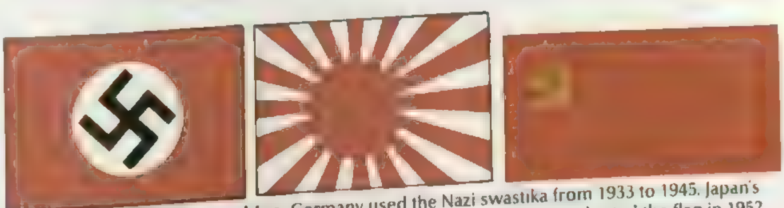
Latin-American flags. Simón Bolívar flew this flag, *left,* in Venezuela and Colombia in 1819. The Army of the Andes raised José de San Martín's flag, *centre,* in Argentina in 1817. The flag of the United Provinces of Central America, *right,* flew from 1823 to 1839.



Flags of four empires disappeared in the early 1900's. The flag of the Chinese Empire, *left,* came down when the empire collapsed in 1912. That of the Russian Empire, *above,* fell during the Russian Revolution of 1917. The imperial flags of Austria-Hungary, *above,* and Germany, *right,* were replaced by flags of republics at the end of World War I in 1918.



Spain's Republican Flag flew from 1931 to the end of the Spanish Civil War in 1939.



Flags under three dictatorships. Germany used the Nazi swastika from 1933 to 1945. Japan's navy flew the rising sun with rays during World War II (1939-1945). It readopted the flag in 1952. The flag of the Soviet Union flew from 1923 until that country was dissolved in 1991.

Kinds of flags

The most familiar type of flag is the national flag. It stands for all the people in a particular country. Similarly, provincial and city flags stand for the people in those smaller areas. But there are many other kinds of flags. Some flags stand for only one person, and others for one part of the government. Some flags are used only by the armed forces, and others only at sea. Some flags are used only to send messages.

National flags

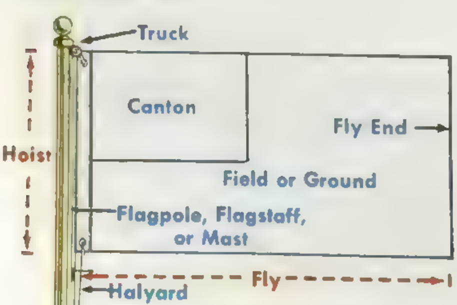
National flags exhibit a great variety of colour and design. While the appearance of some national flags has remained the same for tens or even hundreds of years, other national flags are comparatively recent. Many countries that have gained their independence from colonial rule have adopted a new flag as a symbol of their new-found freedom. The design of a national flag usually symbolizes the nation in some form.

Great Britain's flag is known as the British Union flag, or *Union Jack.* It was officially adopted in 1801. It combines the crosses of St. George for England, St. Andrew for Scotland, and St. Patrick for Ireland.

Australia and New Zealand have included the Union Jack as part of their flags, to symbolize the historic links both countries have with Britain. The flags of Australia and New Zealand also show the Southern Cross, a constellation, or group of stars, visible in the southern hemisphere. Australia's flag also has a single, larger star with seven points, representing the six states and the federal territory of the Commonwealth of Australia. The national flag of Australia is known as the blue ensign.

The *Stars and Stripes* is a popular name for the national flag of the United States of America. It has 13 alternate red and white stripes, representing the 13 original colonies, and 50 white stars on a blue background, representing the 50 present-day states.

Parts of a flag



The *canton* is the upper quarter of the flag next to the staff. The rest of the flag is called the *field* or *ground.* The *fly,* or horizontal length, varies in proportion to the *hoist,* or vertical width, from one flag to another. In the British and Canadian flags, the fly is twice the hoist; in the U.S. flag, it is 1.9 times the hoist; in other flags, it may be 1.5 times the hoist.

Staff ornaments

The ornaments on flagstaffs include, *left to right,* the spread eagle, halberd, ball, flat truck, star, and colours or guidon.

Flags of individuals

Many rulers and important government leaders have personal flags. For example, the British queen and members of the royal family have special flags. The queen's flag, called the *Royal Standard,* is raised over a building as she enters it and lowered when she leaves. The queen also has a *personal standard* for use in the Commonwealth countries that have become republics.

Many personal flags are older than national ones. They developed during the Middle Ages, and became especially important in battle. Noblemen flew banners of various sizes, depending on their rank. With the development of national unity in Europe, flags symbolizing the personal authority of a ruler became less important. National flags representing all the people developed.

Military flags

Flags have always been important in the armed forces. Most countries have special flags for individual units. Some countries also have separate flags for each branch of their armed forces and for top-ranking officers.

Army flags. Armies once went into combat carrying *battle flags.* Some of these army flags were quite different from the national flags of the times. However, soldiers now carry flags mostly for parades and ceremonies. Large units, such as regiments, have special *colours.* These flags often bear the names of the battles or campaigns where the unit served with distinction.

Navy flags. Navy ships usually fly several types of flags. An ensign is displayed when a ship is at sea. It is usually flown from a flagstaff at the stern or from a *gaff* (crossbar) on the mast of the ship. In peacetime, the ensign may not be displayed if the ship is out of sight of land and no other ships are in the vicinity. In wartime, the ensign is always displayed to show the nationality of the ship.

When a navy ship is in port or at anchor, a small flag called the jack flies from the *jackstaff* (short flagpole at the bow), and the ensign is flown from the flagstaff at the stern. Ships of most navies fly *command flags* to show the title or command of any flag officer on board. If no officer higher than the commanding officer is on board, a flag called a *commission pennant* is flown to show the ship is in active service.

Air force flags often are flown over air bases. For example, Britain's Royal Air Force flies a pale-blue ensign with the aircraft recognition emblem used on planes in the ensign's fly. Air force units also have their own flags and *guidons* (small pennants).

Other government flags

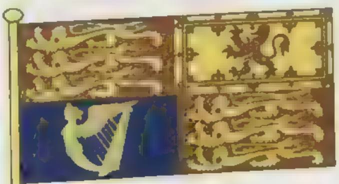
Some countries have a special *state flag* that only the government uses. It flies over government buildings, embassies, and UN headquarters. Usually, a state flag is a national flag with a coat of arms added to it. Most flags in this article are national flags. State flags are shown for Andorra, Argentina, Austria, Bolivia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Ethiopia, Finland, Guatemala, Haiti, Peru, Poland, San Marino, Spain, and Venezuela.

Flag terms

Badge is an emblem or design, usually on the fly.
Battle flag is carried by armed forces on land.
Battle streamer, attached to the flag of a military unit, names battles or campaigns where the unit served with distinction.
Bend on means to attach signal flags to a halyard.
Breadth, a measurement for flags, is 23 centimetres wide. A four-breadth flag is 91 centimetres wide. The term originated when flag cloth was made in 23-centimetre strips.
Bunting is cloth decorated with stripes of the national colours. The term is also used for the woollen cloth used in making flags.
Burgee is a flag or pennant that ends in a swallowtail of two points.
Canton is the upper corner of a flag next to the staff where a special design, such as a union, appears.
Colour is a special flag carried by a military unit or officer. In the armed forces of many countries, regiments and larger units often carry two colours—the national flag and a unit flag.
Courtesy flag is the national flag of the country a merchant ship visits, hoisted as the ship enters port.
Device is an emblem or design, usually on the fly.
Ensign is a national flag flown by a naval ship. Some countries also have ensigns for other armed services.
Ensign staff is the staff at the stern of a ship.
Field is the background colour of a flag.
Fimbriation is a narrow line separating two other colours in a flag.
Flag hoist is a group of signal flags attached to the same halyard and hoisted as a unit.
Fly is the free end of a flag, farthest from the staff. The term is also used for the horizontal length of the flag.
Ground is the background colour of a flag.
Guidon is a small flag carried at the front or right of a military unit to guide the marchers.
Halyard is a rope used to hoist and lower a flag.
Hoist is the part of the flag closest to the staff. The term is also used for the vertical width of a flag.
House flag is flown by a merchant ship to identify the company that owns it.
Jack is a small flag flown at the bow of a ship.
Jackstaff is the staff at the bow of a ship.
Merchant flag is a flag flown by a merchant ship.
National flag is the flag of a country.
Pennant is a triangular or tapering flag.
Pilot flag is flown from a ship that wants the aid of a pilot when entering port.
Reeve means to pull the halyard through the truck, raising or lowering a flag.
Staff is the pole on which a flag hangs.
Standard is a flag around which people rally. Today, the term usually refers to the personal flag of a ruler, such as Great Britain's *Royal Standard.*
State flag is the flag flown by the government of a country. Many state flags are the same as national flags but with the country's coat of arms added.
Truck is the wooden or metal block at the top of a flagpole below the *finial* (staff ornament). It includes a pulley or holes for the halyards.
Union is a design that symbolizes unity. It may appear in the canton, as the stars do in the U.S. flag. Or it may be the entire flag, as in the *Union Jack* of Great Britain.
Vexillology is the study of flag history and symbolism The name comes from the Latin word *vexillum,* which means flag.

A family of flags

Many governments have flags for various purposes. For example, the British have a family of flags. The queen has two flags she can use: the Royal Standard, as queen, and her own standard, as head of the Commonwealth.



The Royal Standard
The queen's flag

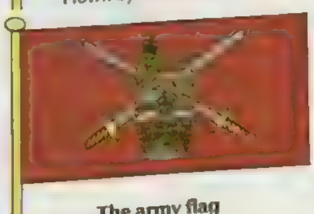
The queen's standard
The queen's personal flag

The Union Jack
The national flag

The Red Ensign
Flown by merchant ships

The Blue Ensign
Flown by public servants

The White Ensign
Flown by naval ships



The army flag
Flown at army bases

The Royal Air Force ensign
Flown at RAF bases

Flags of the sea

A merchant ship flies a *house flag* of the company that owns it. At the stern, it also flies the national flag of the country in which it is registered. The ships of some countries fly a *merchant flag* that differs from the national flag used on land. British ships fly the Red Ensign. When a ship's captain wants a pilot to help the ship enter port, the captain may hoist a *pilot flag*. As a courtesy, ships also fly the flag of the country they visit.

The pirate flag known as the *Jolly Roger* appeared about 1700. It most often featured a white skull and crossbones against a black background.

Signal flags

Flags are often used for signalling. Sailors may use special flags to relay orders to other ships. *Storm warning flags* at coastguard stations and elsewhere provide warnings of hazardous wind and sea conditions.

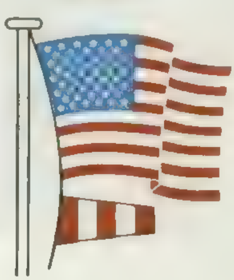
Hand signal flags. In signalling, a *wigwag flag* is used to indicate the dots and dashes of the Morse code (see **Morse code**). A signaller uses two *semaphore flags* to spell out a message, holding them in various positions to indicate letters and numerals (see **Semaphore**).

The international flag code, the most complete flag signalling system, has more than 40 flags. Each flag stands for a letter of the alphabet and pennants stand for zero and the numerals 1 to 9. To send messages, sailors fly *hoists* of one to five flags that have code meanings or spell out words.

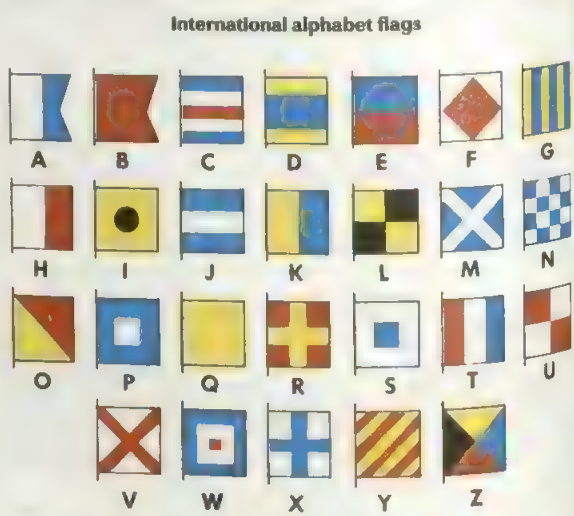
Each ship carries a code book that explains the flags in nine languages—English, French, German, Greek, Italian, Japanese, Norwegian, Russian, and Spanish. With the code book, any captain can understand messages sent to the ship. Warships fly the *code and answering pennant* when they use the international code, so other ships will know that they are not using a secret code.

Sailors use certain flags from the international code for warnings or announcements. A ship in harbour that is about to sail hoists the flag for the letter *P*, a flag once known as the *blue peter*. A ship flies the *D* if it is having difficulty steering, and the *O* if it has lost someone overboard. The flags for the letters *I* and *T* together warn that a ship is on fire; and the signal *M, A,* and *A* requests urgent medical advice.

Ships use the international flag code to aid communication at sea. Flags are hoisted to send messages to other ships or to shore, *above*. The flags are being hoisted in a signalling drill.

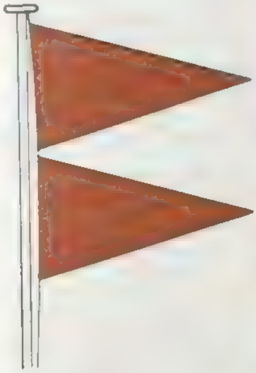


International flag code includes a code and answering pennant flown beneath the national flag, *above*, as well as flags for letters and numerals and substitutes, *right*. A ship receiving a signal raises its answering pennant to show that the message—or *hoist*—has been understood. Substitutes repeat any flag that precedes them.

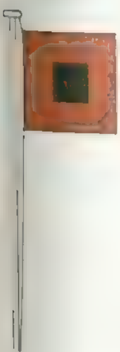


Storm warning flags fly at shore stations to warn boats of hazardous wind and sea conditions. The red or red-and-black flags are designed to be visible even from a distance.

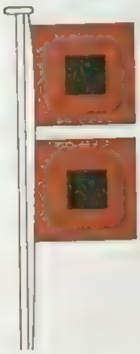
Small craft advisory
Winds up to
61 kph



Gale warning
Winds from
63 to 87 kph

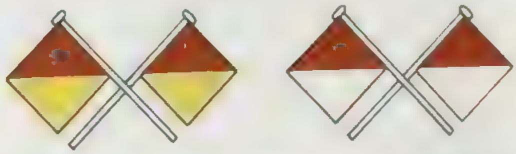


Storm warning
Winds from
89 to 117 kph

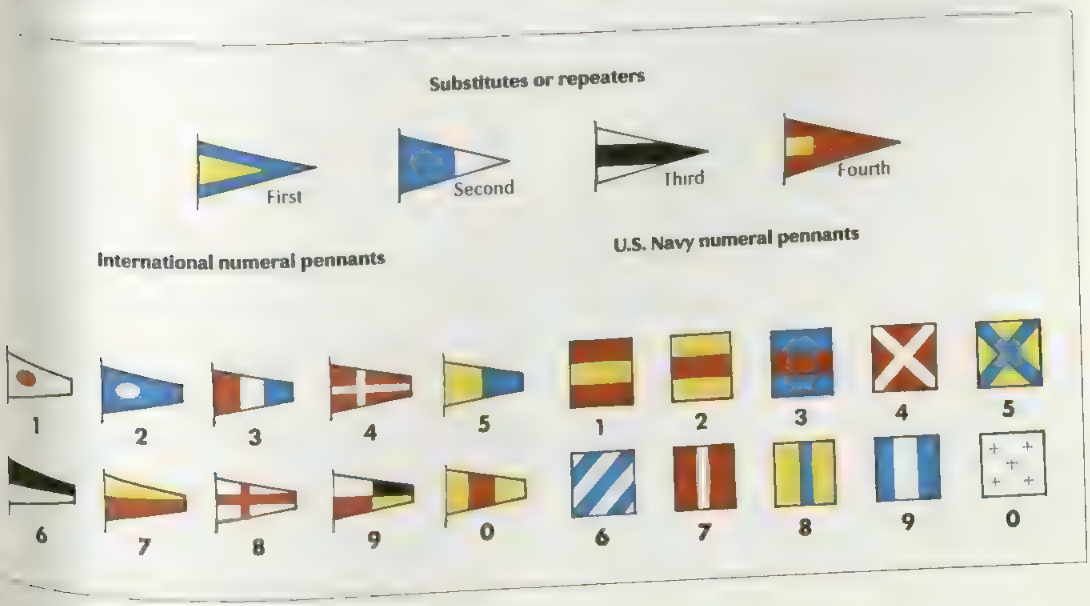


Hurricane warning
Winds at least
119 kph

A signalman uses semaphore flags to send a message to the crew of another ship. The signalman holds the flags in various positions to indicate letters and numbers.



Semaphore flags are used to send messages between ships or between a ship and shore. Red-and-yellow flags, *left,* are used at sea, and red-and-white ones, *right,* on land.



Rules for flag use

The rules for handling, displaying, and treating a country's flag differ from country to country, but all have some things in common.

Displaying the flag

In any country, the national flag takes precedence over the flags of other nations, provinces, states, cities, or towns. The United Nations flag is an exception to this rule. It must be flown in a way that gives it equal status with any national flag flown near it.

The flag of the head of state takes precedence over the national flag. In the United States, the same is true of the church pennant flown at sea, which can even take precedence over the President's Standard (Colour).

Flag codes. Many countries have legal codes or sets of rules to show the correct way of using the national flag. For example, the United States flag code of 1942 describes in detail the right and wrong ways to display the national flag. It also contains a flag pledge used in American schools to tell students how to salute their flag. Australia, India, and Ireland have similar codes, although they do not have the force of law. Several Australian states have codes similar to that of the United States. The New Zealand Flag Act of 1981 does not set out rules for flying the flag, but it does define who can fly the national flag and when. The Indian flag code forbids the imitation of the flag for use as a trade mark. Trinidad and Tobago has a book of rules covering both display and protection of the national flag. The United Kingdom has merely a list of dates when the national flag should be flown from public buildings.

When flags are flown. The national flag of a country is always flown on the country's national day or days, such as Independence Day in the United States. The national flag is also flown on the birthday of the head of state. Flags are flown on days that commemorate a famous historic event, such as Bastille Day in France. National heroes are also honoured by the flying of flags; Mohandas Gandhi's birthday is marked in this way in India. Flags are flown on major religious holidays, such as Ascension Day in Spain, and on the feasts of patron saints, such as St. George's Day in England. Most countries fly flags on civil holidays, such as May Day in several countries, and on international days such as United Nations Day. In some countries, such as the United States, the national flag is displayed every day.

According to most flag codes, flags should be flown only during the hours of daylight, unless floodlit. At Athelstaneford, in Scotland, the flag of St. Andrew is flown night and day to commemorate the adoption of the saltire, or St. Andrew's cross, by an early king of Scotland. Armed forces' codes specify the hours of daylight, and these can vary from winter to summer. Flags are not usually flown in very bad weather.

Where flags are flown. Official flags are flown from the buildings of the government, military establishments, national monuments, and memorials; and in public squares, schools and colleges, and most public places. The flags of heads of state are usually flown only when the person in question is actually present. The royal standard of the United Kingdom is flown only on Buckingham Palace, in London, or other places when the Queen is in residence, and on the royal yacht when she is on board. In Canada, the national flag flies over the Parliament Building in Ottawa only when the legislature is in session. The Australian flag flies permanently over the Federal Parliament in Canberra, where it is floodlit.

Some countries make an important distinction between the state flag, which is reserved for the government, and the civil flag, which is used by the ordinary citizens. In Germany, flags bearing the state arms are reserved for government use. German manufacturers refuse to supply these flags to ordinary customers. Similarly, in Hong Kong and other British dependencies, the government flag is not on sale to the public.

In Britain, the civil population can use the national flag on land, but at sea a special flag, known as the Red Ensign, must be used. Special civil ensigns are also stipulated in other countries, including Hong Kong, India, Italy, Malaysia, Malta, New Zealand, and Singapore.

In Denmark, it is considered bad manners to leave a flagstaff without a flag on it, so special long, narrow pennants in the design of the national flag are provided These hang from the staffs on occasions when no flag is being flown—for example, when a building is empty. Similar pennants are used in other Scandinavian countries, Germany, and the Netherlands.

Raising and lowering the flag

A national flag should be *hoisted* (run up) briskly. It is lowered slowly, and should be gathered and folded before it touches the ground. When displayed with other flags from several staffs, the national flag should be raised first and lowered last.

Dipping the flag. Flags can be used to give salutes to important people, such as a head of state or leader of government. In a parade, this is done by lowering the staff carrying the flag from its normal vertical carrying position to a horizontal position. A further dip, only performed when the flagbearer is standing still, lowers the staff so that the flag trails on the ground. In Britain, this is called "dipping for royalty" and is done only before the sovereign. Few other countries permit this form of salute. In Ireland, a flag carried on parade can only be dipped at a religious ceremony when the sacred host is being elevated. The flag codes of India, the United States, and several other countries forbid the national flag being dipped at all. At sea, a flag is dipped by lowering it from the masthead and then raising it again.

Flag at half-mast. Flags are flown at *half-mast* (halfway up the staff) as a sign of mourning. Half-mast means one flag-width down the mast, and the flag is always hoisted fully to start with. Most countries permit their national flag to be flown at half-mast only on special occasions. In Britain and most Commonwealth countries, this means only on the death of the sovereign, and even then for only part of the day. An alternative to flying the flag at half-mast is to add a wreath or bunch of black mourning ribbons to the flag.

Saluting the flag. In most countries, people salute the national flag when it is being hoisted, or passing by in a parade, or being displayed while the national anthem is being played. The United States flag code, and codes like that of Ireland, which are derived from it, require civilians to salute by putting their right hands over their hearts. Men wearing hats must remove them. In most countries, however, people merely stand to atten-

tion. The United States is alone in having a special form of words to salute the flag, called the Pledge of Allegiance.

Flying the flag upside down is used as a sign of distress. Sometimes a flag is hoisted upside down by mistake. The British flag is often hoisted upside down because the difference between the two positions is not easy to see. In the correct position, the broad white diagonal stripe is uppermost in the top section near the flagstaff. The flag of the Philippines is flown upside down in time of war.

Flags at funerals. Flags can be used to cover the coffin of a deceased member of the armed forces, police, or fire brigade. Australia and the United States differ from other countries in placing the *upper hoist* (the part of the flag containing the canton) over the upper left-hand corner of the coffin. In most other countries, the flag is placed just as it would be if hung vertically, that is, with the upper hoist on the observer's left. It is usual for the flag that has draped the coffin to be given to the chief mourner after the ceremony. It is never buried with the coffin, or, indeed, allowed to touch the ground. During a burial at sea, the coffin is covered with the flag. When the coffin is dropped into the sea, the flag remains on board the ship. The United States is unique in flying small flags on the graves of ex-members of the armed forces.

Honouring the flag

Swearing on the flag. In many countries, recruits to the armed forces take an oath of allegiance holding the flag or the flagstaff. Boy Scouts have a similar ceremony. This shows that we think of the flag as a holy object, which can add value to an oath.

Disposing of old flags. Military colours and old national flags are often hung up in cathedrals or other sacred places. Old flags gradually fall to pieces. However, some historic flags are now conserved in controlled environments. The United States has a ceremony for cremating flags in an honourable way, and this is also recommended in the Australian flag code.

Independence ceremonies. Many of the countries that became independent in the years following World War II (1939-1945) did so with a ceremony that involved hoisting their new national flag in place of the old colonial flag. The Philippines did this on July 4, 1946. India and Pakistan became independent in 1947. The flags of the new nations were actually hoisted on the stroke of midnight preceding the first day of independence. Some Commonwealth countries, such as Malaysia, New Zealand, and Singapore, had flags before they became independent. Others, such as Canada and South Africa, adopted their present flags only after becoming independent.

Flags to mark achievements. In the past, flags were often hoisted to mark the conquest or claiming of a territory. Columbus raised the Spanish flag when he landed on Watling Island on Oct. 12, 1492. The British flag was hoisted in Australia for the first time in 1770 by Captain James Cook. A famous American military monument commemorates the hoisting of the U.S. flag on the Japanese island of Iwo Jima in 1945. Mountaineers have set flags on top of Mount Everest. Astronauts planted the U.S. flag on the moon.

Flag etiquette

Some practicalities. Flag codes usually forbid the use of a country's national flag for advertising, and especially the addition of a slogan or company logo to it. Flag codes also forbid the use of the flag as a drape or covering, for example, as a table covering.

In the United States, it is common to display the national flag in courtrooms and churches. The flag should always be on the right of the judge or altar. This is not done in most parts of the world, although the national arms are traditionally displayed in courtrooms.

The national flag should not be allowed to touch the ground when being lowered, but should be gathered over the shoulder while being detached. In military use, the flag is then folded into a neat shape. When the national flag is hung vertically, the upper hoist is on the observer's left, as is stipulated in the Indian flag code.

Flag desecration. Few countries have any specific laws to prevent flag *desecration* (abuse). The United States flag code lists many prohibited usages, including using the flag as part of clothing or bedding. No such bans exist in the United Kingdom. The New Zealand flag code specifically states that it is unlawful to damage or destroy the flag, but this kind of legislation is unusual. In most countries, public order laws protect national flags from deliberate public desecration.

Flags are sometimes deliberately destroyed, damaged, or desecrated in order to make a political point. Captured ships, which have been obliged to *strike* (lower) their colours, have their ensigns flown underneath those of their captors.

Forbidden flags. Some countries have laws to prevent the use of one or more specified flags. In the United States, some states have laws banning the use of red or black flags. In Northern Ireland, there is a law to prevent the use of the Irish tricolour. In Israel and its occupied territories, the flag of the Palestine Liberation Organization is outlawed. In Germany, it is forbidden to display Nazi emblems and flags. In general, however, the right to display a flag is a basic human freedom.

Related articles in *World Book* include:

Heraldry	Navy Jack	Semaphore
Jones, John Paul	Pledge of Allegiance	Tricolour
Key, Francis Scott	Ross, Betsy	Union Jack

Outline

I. Flags of the world
II. Kinds of flags
- A. National flags
- B. Flags of individuals
- C. Military flags
- D. Other government flags
- E. Flags of the sea
- F. Signal flags

III. Rules for flag use
- A. Displaying the flag
- B. Raising and lowering the flag
- C. Honouring the flag
- D. Flag etiquette

Questions

What country has used the same national flag for over 750 years?
How does the *union* of a flag differ from the *canton*?
When is a national flag flown at half-mast?
Who flew the first flaglike emblems?
What is the *hoist* of a flag? The *fly*?
How are most flags made?
What is the meaning of *dipping* a flag? Of *striking*?
How can ship captains understand signals at sea?

Flag of truce is a plain white flag used by opposing sides on a battlefield when they want to discuss peace terms. Both sides can stop fighting while their leaders discuss the terms of the truce. It is also used to arrange for a prisoner exchange or for wounded to be rescued. All armies throughout the world recognize the flag of truce.

Flagellate. See **Protozoan** (Kinds).

Flagellum is the singular form of flagella. See **Protozoan** (Kinds); **Bacteria** (How bacteria move).

Flageolet is a small woodwind instrument that belongs to the flute family. Closely related to the recorder, it consists of a wooden or metal tube with a mouthpiece at one end. The tube has four finger holes on top and two thumb holes underneath. A player holds the flageolet vertically and blows through the mouthpiece. The flageolet has a high sound similar to that of the piccolo, but somewhat softer. Sieur Juvigny, a French musician, invented the flageolet in 1581. The instrument gained great popularity in the 1600's.

The flageolet is played by blowing through one end and opening and closing finger and thumb holes.

Flagstad, Kirsten (1895-1962), a Norwegian operatic soprano, became famous as an interpreter of the heroines in the operas of Richard Wagner. Previously unknown to American audiences, her 1935 debut as Sieglinde in *Die Walküre* at the Metropolitan Opera House in New York City was a storybook triumph. Flagstad also became a renowned recitalist. She helped revive interest in the songs of her countryman, Edvard Grieg. Although she retired from the operatic stage in 1952, she continued to sing in concerts and to record opera and German songs. She became director of the new Norwegian State Opera in 1958. Born in Oslo, Flagstad made her operatic debut there when she was 18 years old.

Flaherty, Robert Joseph (1884-1951), was a pioneer American filmmaker. He is considered the father of documentary films. Flaherty became noted for his treatment of the lives of isolated peoples in the silent films *Nanook of the North* (1922) and *Moana* (1926) and in the sound film *Man of Aran* (1934). His short film *The Land* (1942) showed the effects of erosion on the landscape. *Louisiana Story* (1948) portrayed the impact of the discovery of oil on a poor family that lived in the bayous (lake outlets) of Louisiana, U.S.A.

Flaherty was born in Iron Mountain, Michigan, U.S.A. He codirected the feature films *White Shadows of the South Seas* (1927) with W. S. Van Dyke, *Tabu* (1931) with F. W. Murnau, and *Elephant Boy* (1937) with Zoltan Korda. Flaherty's wife, Frances Hubbard Flaherty, worked on several of his documentaries.

Flail is a hand implement used to thresh small grain crops such as wheat, barley, and oats. The flail was a short stick or club fastened by a leather strip to a long wooden handle. Farmers used it to beat the grain from the straw. Then they tossed the mixture of grain and straw into the air to be separated by the wind or by fanning it with a large sheet. The threshing machine and the motor-operated combine harvester have replaced the flail on most farms. However, it is still used in some developing countries.

In early days, people also used flails as weapons. The flail then usually consisted of a wooden bar or ball studded with metal spikes or barbs. It was joined to a short handle by a length of chain.

Flame. See **Fire.**

Flame test is a way of identifying a chemical element by the colour of the light it gives off when held in a flame. For most elements, the test can be made by dipping a platinum wire in a compound of the element, either powdered or in solution. The wire is then held in the flame of a Bunsen burner (see **Bunsen burner**).

An element always gives off a flame of the same colour. For example, compounds of barium colour the flame yellowish green. Flames of calcium are orange-red. Copper gives off an emerald-green colour when held in a flame. Lithium's flame is deep red. Sodium's flame is yellow. Strontium gives off a crimson flame. Potassium's flame is violet.

See also **Mineral** (Other identification tests).

Flame thrower is a weapon of war that shoots a stream of burning fuel in much the same way that a fire hose squirts water. The flame belches from the nozzle of a flame gun, which is connected by a flexible tube to two tanks of fuel on the operator's back. A tank of compressed air between the tanks of fuel provides the pressure needed to squirt the fuel through the gun. Portable flame throwers weigh a total of about 30 kilograms when they are ready to fire.

The Germans introduced flame throwers during World War I (1914-1918), but they were not widely used until United States soldiers used them against the Japanese in World War II (1939-1945). Soldiers used flame throwers against fortifications that could not be captured with rifle fire alone. Flame throwers became a weapon to be feared by the enemy. Soldiers who scoffed at rifle bullets often fled in panic at sight of the long, searing tongue of flame licking toward them.

The fuel used in flame throwers during World War I was a mixture of petrol and oil. During World War II, a jellied petrol called *napalm* was developed (see **Napalm**). By using napalm, soldiers could fire portable flame throwers up to about 60 metres. Flame throwers that were mounted on tanks could reach targets up to 230 metres away. When the jellied fuel hit a target, it scattered into sticky blobs. These blobs could bounce through small openings and into fortifications. The napalm would stick to the target and prove very difficult to extinguish.

Since the 1940's, flame throwers have served important functions in civilian life. Farmers make much use of flame throwers to burn weeds and destroy such harmful

A flame thrower can hurl a tongue of flame 60 metres. The operator carries two tanks of fuel and a tank of compressed air to provide the pressure needed to squirt the fuel through the gun. When ready to fire, the portable flame thrower weighs about 32 kilograms.

insects as tent caterpillars. Flame throwers can also break rocks and melt snow.

Flame tree is one of Australia's most colourful trees. In summer, the trees display cone-shaped flower heads that look like waxy red bells. Flame trees grow to about 30 metres high, and tower above the other forest trees.

Flame tree is one of Australia's most colourful trees. In summer, it has red, cone-shaped flowers.

They are found in coastal brush forest of Queensland and New South Wales.

Scientific classification. The flame tree belongs to the largely tropical family Sterculiaceae. It is *Brachychiton acerifolius.*

Flamenco is a type of dance and music first performed by the Gypsies of southern Spain. Flamenco dancing exists both in a folk form and in a version for stage performance. In either style, a performer must improvise and add a personal interpretation to the dance. Flamenco dancing may include much skilful footwork, finger snapping, and forceful but flowing arm movements.

Flamenco dances may be performed by a single person, a couple, or a larger group. The best flamenco dancers are inspired by a passionate spirit and communicate their energy to the audience. Colourful costumes and much noise contribute to the excitement of the performance.

Originally, flamenco dancers were accompanied by clapping, singing, and stamping. Later, castanets and guitars were added. The musicians provide a basic, repetitive yet varied rhythm.

See also **Spain** (picture: The flamenco).

Flamingo is a bird known for its long, stiltlike legs and curved bill and neck. Flamingos live in many parts of the world and spend their entire life near lakes, marshes, and seas.

Most flamingos stand between 90 and 150 centimetres tall. The colour of a flamingo's feathers—except for some black wing feathers—ranges from bright red to pale pink. For example, flamingos of the Caribbean area have coral-red feathers, and South American flamingos have pinkish-white feathers. Most flamingos eat small animals such as copepods, and small water plants called *algae.* Hairlike "combs" along the edges of the bill strain mud and sand from the food a flamingo finds in the water. The feet of flamingos are webbed, as are those of ducks and other birds that spend much time in water.

Flamingos live in colonies, some of which have thousands of members. They mate once a year. Flamingos build a nest that consists of a mound of mud. Most of the females lay a single egg in a shallow hole at the top of the nest. The parents take turns sitting on the egg to keep it warm. The egg hatches after about 30 days. Young flamingos leave the nest after about 5 days and form small groups. But the young flamingos return to the nest to feed on a fluid produced in the digestive system of the parents. The adults dribble this fluid from their mouth into the youngster's bill. After about two weeks, the young form larger flocks and start to find their own food. Flamingos live from 15 to 20 years in their natural surroundings. They live even longer in captivity.

Most zoologists classify flamingos into four species. The *greater flamingo* lives in Africa, southern Asia, southern Europe, southern South America, and the West Indies. In Europe, two nature reserves are famous for their flamingo colonies. These are the Camargue, in the south of France, and the Coto Dônana in southern Spain. The *lesser flamingo* lives in the Great Rift Valley of Kenya and Tanzania, in Africa. The other two species, the rare *Andean* and *James'* flamingos, dwell near the highland lakes of the Andes Mountains in South Amer-

Flamingos live in marshy areas in many parts of the world. These graceful birds feed on small organisms that they find in muddy water.

A young flamingo, *right,* lacks the large, bent bill and pinkish colour of the adults. The young first leave the nest about five days after hatching.

ica. Wild flamingos once lived in southern Florida, U.S.A., but people killed them for their beautiful feathers faster than the birds could multiply.

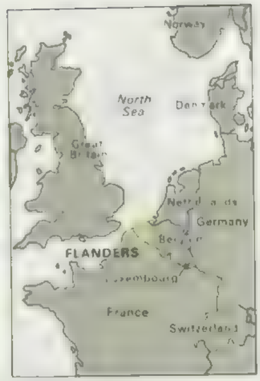
Scientific classification. Flamingos belong to the flamingo family, Phoenicopteridae. The greater flamingo is *Phoenicopterus ruber.*

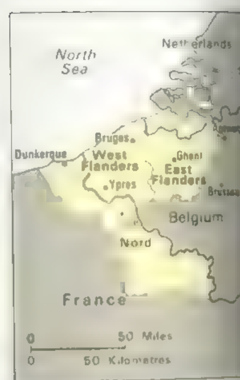
See also **Bird** (How birds feed [picture: The flamingo]).

Flammarion, Camille (1842-1925), a Frenchman, was one of the most imaginative and colourful writers of science books. He greatly influenced the young people of many countries, and helped turn their interest to astronomy. His most famous work, *Popular Astronomy* (1877), became a best seller.

Flammarion was born in Montigny-le-Roi, France, and lived in or near Paris throughout his life. The poverty of his parents forced him to seek work as an engraver. He became interested in astronomy, and in 1883 founded an observatory near Paris. There he studied the moon, Mars, and double stars. Later in life, he turned to more controversial work on *psychical research* (research into supernatural phenomena).

Flanders is a part of northern Europe that was a separate political unit until modern times. Two-thirds of the historic Flanders region now forms the provinces of East and West Flanders in northern Belgium and extends slightly into the Netherlands. The rest of Flanders is the northern half of the French *department* (administrative district) of Nord. Flanders is an area of rich soils, which are low lying and difficult to drain. The farms near the coast are protected by dikes and drained by canals. Farmers produce hops, fodder, wheat, flax, and sugar beets. Industries in Flanders include coal-mining and the manufacture of cars, textiles, and a variety of metal and electrical goods.





Flanders is a historic region in Europe.

The early products of Flanders were wool and flax for use in the manufacture of cloth. A heavy trade in wool began, especially with England. As a result, cities developed earlier in Flanders than in most of Europe. Flanders was the market place of the continent during the 1300's and 1400's. The great trading fairs that were held in the city of Antwerp—which was then part of the historic Flanders region—brought fame and wealth to the city. Ypres, Bruges, and Ghent also grew rich through trade.

The dense population and the wealth of Flanders led to the development of a distinct Flemish culture. This culture was marked by a concern for painting, architecture, literature, and other refinements that gave Flanders a leading place in early European civilization.

For many years, Flanders was ruled by a succession of powerful nobles, each of whom was known as the Count of Flanders. In the early 1800's, Napoleon I made Flanders part of the French Empire. The present division of the historic Flanders region among Belgium, France, and the Netherlands was made in 1830.

Today, the name *Flanders* also refers to a Dutch-speaking region in the northern part of Belgium that has limited self-rule. This region of Belgium consists of the provinces of Antwerp, East Flanders, West Flanders, Limburg, and the northern half of Brabant (see **Flemings**).

See also **Ghent; Painting** (The Renaissance in Flanders).

Flannel is a soft, warm fabric. It is made from wool and from blends that consist of wool and cotton or rayon. Manufacturers usually brush flannel to give it a *napped* (raised) surface. Most kinds of flannel are produced in the *twill weave*—that is, they have a pattern of raised, diagonal lines woven into them. Some flannels have a flat texture made by using a *plain weave.* Flannel is used chiefly in suits and coats.

A soft fabric called *flannelette* resembles flannel and is often confused with it. It has a napped surface like that of true flannel, but unlike flannel, flannelette is normally made entirely from cotton. Flannelette is used mainly for baby clothing, bed linen, nightgowns, pyjamas, and shirts.

Flannel flowers grow in many parts of Australia and New Zealand. These plants have a central disc of small,

Flannel flowers grow in Australia and New Zealand.

woolly flowers surrounded by a ring of woolly *bracts* (leaves). The bracts are white with delicate green tips.

The two largest and most attractive varieties of flannel flowers grow on the exposed sandy plateaus of eastern Australia and on the sandy heath of Western Australia. The east coast flannel flower is a shrub about a metre high, with woolly, grey, divided leaves and flower heads like flannel daisies. Each of the flower heads grows to about 75 millimetres in diameter. The west coast flannel flower is most attractive, with a central disc of creamy-white and feathery bracts.

Scientific classification. Flannel flowers belong to the parsley family, Umbelliferae (Apiaceae), genus *Actinotus.* There are about 16 species in Australia and 1 in New Zealand.

Flaps. See **Aeroplane** (The wing).

Flare, Solar. See **Sun** (Flares; The sun's brightness; Sun terms; The sun's stormy activity).

Flashbulb. See **Photography** (Lighting equipment).

Flat-coated retriever is considered a gamekeeper's dog in Great Britain. It was bred from two North American dogs, the Labrador retriever and the St. Johns Newfoundland. The dog was first introduced in England, in 1860. It has a thick, fine, flat coat, and is usually solid black or solid *liver* (reddish-brown). The dog weighs between about 27 and 32 kilograms, and stands about 56 centimetres high at the shoulder.

The flat-coated retriever has a thick coat.

Flatboats on the Ohio River carried thousands of immigrants to new settlements in the Midwestern United States during the early 1800's.

Flatboat is a large, raftlike barge used to haul freight and passengers. A flatboat has a flat bottom and square ends. A *keelboat,* sometimes called a flatboat, was a long narrow craft, sharp at one or both ends. It was built on a keel and ribs. These boats carried the furniture and livestock of thousands of immigrants to new settlements in the Midwestern United States during the early 1800's. The boats were moved by the current and by long oars which were also used for steering. A vast flatboat freight business developed on the Mississippi and other rivers.

Flatfish is a name given to several saltwater fish. These fish have a body that appears to be flattened horizontally. The fish actually lies on its side, with both eyes on the same side of the head. When the flatfish is first hatched, it looks like any other kind of fish. But after it has grown to about 20 millimetres long, one eye begins to move closer to the eye on the opposite side of the head, and the mouth becomes twisted. The eyeless side of the fish becomes its underside and loses its colour. The new upper side becomes darker. The fish becomes coloured to blend with its surroundings. About 130 kinds of flatfish live in the Atlantic and Pacific oceans, including the flounder and sole. See also **Flounder; Halibut; Plaice; Sole; Turbot; Animal** (picture: Animal camouflage).

Scientific classification. Flatfish make up the order Pleuronectiformes.

Flatfoot is an inherited condition in which the long arch of the foot appears to be flat or collapsed. The condition results from weak ligaments that are unable to support the arch. Many people believe that flat feet cause pain. As a rule, this is not so, because the height of the arch does not affect how the foot functions. However, the condition may cause discomfort, which may be eased by the use of shoes designed to support the arches.

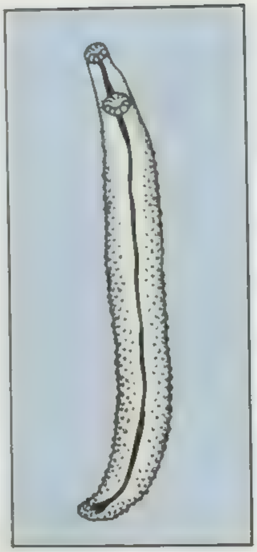
Flattop. See **Aircraft carrier.**

Flatworm is a kind of worm. Some flatworms live freely on land or in water. Others live as parasites in human beings or other animals. Many flatworms, especially the larger *species* (kinds), have a flat body, but some are cylindrical in shape.

Flatworms have a simple body structure. A layer of cells called the epidermis covers the animal's body. An

inner layer of cells forms an intestine in most flatworms. A tightly packed mass of cells called the *parenchyma* fills the body between the epidermis and intestine. Muscles, glands, nerves, and reproductive organs lie in the parenchyma. The only opening of the intestine is the animal's mouth. The mouth may be at the head end, the rear end, or the underside of the body.

Many flatworms have a smooth, soft body. Many have suckers or other projections on the body. Some flatworms have spines and tiny, needlelike *spicules* that serve as a kind of skeleton. Most flatworms measure less than 2.5 centimetres long. However, the largest flatworms, called *tapeworms,* may grow up to 30 metres long.



The blood fluke may inhabit the blood vessels of the abdomen of human beings. This flatworm causes schistosomiasis, a disabling disease common in tropical regions.

There are about 25,000 species of flatworms. They may be divided into four groups: (1) turbellarians; (2) monogeneans; (3) trematodes; and (4) cestodes, or tapeworms. Most turbellarians are free-living. They usually are found in sand and mud on the bottom of bodies of water. A few species live on land in moist soil. The other three groups of flatworms are parasites. They live in a wide variety of organisms that serve as *hosts.* Monogeneans and trematodes are commonly called flukes.

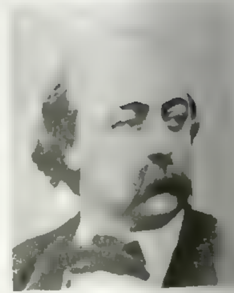
Almost all flatworms are *hermaphroditic*—that is, both male and female reproductive organs are found in the same animal. Most turbellarians lay eggs that hatch into tiny young that resemble the adults. In some turbellarians, and in all parasitic flatworms, young called *larvae* hatch from the eggs. The larvae look different from the adults and live in different habitats. For example, the larva of a monogenean has hairlike *cilia* that enable it to swim. The larva swims until it finds an appropriate fish for a host. The larva attaches to the fish and develops into an adult. The adult, which lives on the skin and gills of the fish, lacks cilia and cannot swim.

Parasitic flatworms cause disease in their hosts. Schistosomiasis, for example, is a tropical disease caused by *schistosomes* (blood flukes) living in the blood vessels of the abdomen (see **Schistosomiasis**). Adult tapeworms that live in the intestine of human beings do not usually cause much harm. However, tapeworm larvae cause serious diseases that can be fatal if not treated.

Scientific classification. Flatworms make up the phylum Platyhelminthes. The four classes of flatworms are Turbellaria, Monogenea, Trematoda, and Cestoda.

See also **Animal** (picture: Animals of the oceans); **Fluke; Planarian; Tapeworm; Worm.**

Flaubert, Gustave (1821-1880), was a French writer whose novels contain some of the most vivid and lifelike characters and descriptions in literature. Flaubert blends precise observation with a careful attention to language and form. His *Madame Bovary* is considered perhaps the most perfect French novel.



Gustave Flaubert

Flaubert was born in Rouen, France. He lived alone, devoting himself to literature. His adoration of artistic beauty was paralleled by his hatred of materialism.

Flaubert tended to be both a sceptic and a pessimist. His works are never sentimental or soft, but they are always deeply human. His novels show he was also a realist and a romantic. The realism can be seen in his attention to detail and his objective description of characters and events. The romanticism appears in the exotic subject matter that Flaubert chose. *Madame Bovary* (1856) is a poetically realistic treatment of a case of adultery in a village in Normandy, France. *Salammbô* (1862) is a colourful novel about ancient Carthage. *A Sentimental Education* (1869), a kind of autobiography, is an example of strict literary realism. *The Temptation of St. Anthony* (1874) is a marvellous fantasy. *Three Tales* (1877) contains three small masterpieces, each illustrating a different style: "A Simple Heart" (contemporary realism), "Herodias" (Biblical style), and "The Legend of St. Julian the Hospitaller" (medieval style). The novel *Bouvard and Pecuchet,* which was unfinished when Flaubert died, was published in 1881.

Flavian Amphitheatre. See Colosseum.

Flax is a plant grown for its fibre and seed. The fibre is made into linen fabric and a variety of other products, including rope, thread, and high-quality paper. The seeds contain *linseed oil,* which is used primarily in the production of paints and varnishes. It also has some medicinal uses.

There are about 230 species of flax. Only one species, *Linum usitatissimum,* is grown commercially. Different varieties of this species are grown for fibre and for seed.

The flax plant stands between about 0.5 and 1.5 metres high and has either white or blue flowers. The variety grown for fibre has a slender stem that branches near the top. Seed flax is bushier than fibre flax and bears more seeds.

Flax may be attacked by a number of fungal diseases, including *rust, wilt,* and *pasmo.* Before planting flax, farmers treat the seeds with chemicals called *fungicides* to provide protection against these diseases. Farmers also plant disease-resistant varieties of flax.

World production of fibre flax amounts to about 714,000 metric tons annually. Before its breakup, the Soviet Union accounted for almost half the production. Other leading growers included China, France, Romania, and Poland, in that order. World flaxseed production totals about 2,500,000 metric tons yearly. Leading flaxseed-producing countries include Canada, Argentina, India, and China.

Growing and processing fibre flax. Fibre flax grows best in cool, moist climates with rainy summers.

It is planted in the spring after the danger of frost has passed. It is generally grown in rotation with other crops. Rotation helps reduce the effects of diseases. See Cropping system.

Fibre flax is harvested three to four months after planting. If the plants are harvested too early, the fibres will be fine and silky, but weak. If the plants become too ripe, the fibres will be stiff and rough and difficult to spin into yarn. Farmers harvest fibre flax with a machine that pulls the stalks from the ground. On some farms, workers harvest the plant by hand.

After the plants have been harvested, the flax stems are soaked in water. This process, which is called *retting,* rots the stalk and exposes the fibres that lie under the woody part of the stem. There are two methods of retting—*dew retting* and *water retting.* In dew retting, farmers spread the flax in the field and allow the dew to rot the plants for several weeks. During the dew retting process, the stems are turned several times and the seeds are removed. In water retting, the seeds are removed first and the stems are then soaked in large tanks of warm water for four to eight days.

After retting, the flax stems are dried and sent through a machine that breaks them into small pieces called *shives.* Next, in a process called *scutching,* the machine separates the shives from the fibres by beating the stems with a whirling paddle or blade. In the next step, called *hackling,* the *tow* (short) and *line* (long) fibres are straightened and separated from each other by combing. The fibres are then baled and sent to mills for processing. The seeds that were removed from the plants are processed for oil.

Growing and processing seed flax. Seed flax grows best in areas with cool climates and dry summers. Most seed flax is planted in early spring. In the autumn, harvesters reap the flax and separate the seeds from the rest of the plant. The seeds are then shipped to mills to be processed.

In the mill, the flax seeds are ground into a meal and then steamed. The oil is then removed either by squeezing the meal in a hydraulic press or by treating the meal with chemicals called *solvents.* Flax seeds consist of about 40 per cent oil and 60 per cent water and solid matter. Twenty-five kilograms of seeds produces about 9.5 litres of linseed oil. The meal that remains after processing is used as a high-protein feed for livestock.

In some countries the unused portions of the seed flax plant are processed to remove the tow fibres. The fibres are made into yarn and into paper for cigarettes, Bibles, and other products.

Leading flaxseed-producing countries

*Figure is for period prior to the country's breakup.
Figures are for a three-year average, 1988-1990.
Source: Food and Agriculture Organization of the United Nations.

History. Flax is one of the oldest cultivated crops. Flax seeds found in Syria and Turkey indicate that the plant might have been grown as early as 7000 B.C. The Egyptians began growing flax about 5000 B.C. By about 1000 B.C., the cultivation of flax had spread to Western Europe. In the A.D. 700's, the areas that are now Belgium and France became leading producers of fine linen. Ireland is still a famous producer of fine linen.

The invention of a cotton gin by the American Eli Whitney in 1793 made cotton yarn more economical than linen yarn. As a result, some flax-producing countries abandoned fibre flax production. Flaxseed production has generally declined since the 1950's because of

Flax is valued for its seeds and its fibres. Seed flax, *left,* produces linseed oil. Fibre flax, *centre,* is used to make linen. Farmers use a machine to harvest fibre flax, *right.*

John Flaxman's marble relief sculpture of Apollo and Marpessa gained him a diploma at the Royal Academy of Arts.

the increasing popularity of emulsion paints over oil-based paints.

Scientific classification. Flax belongs to the family Linaceae and makes up the genus *Linum*.

See also **Linen; Linseed oil.**

Flaxman, John (1755-1826), a British designer and sculptor, is best known for his delicate and graceful designs for Wedgwood pottery. He produced designs for Josiah Wedgwood from 1775 to 1787 (see **Wedgwood, Josiah**).

Flaxman also carved monuments for churches. Among the most notable of them is the monument to Lord Mansfield in Westminster Abbey, in London. He also designed illustrations for classical works of literature.

John Flaxman

Flaxman was born in York in the north of England and educated at the Royal Academy of Arts in London. He was made a royal academician in 1800. Flaxman became professor of sculpture at the Royal Academy in 1810.

Flea is a small, wingless insect that lives on mammals and birds, and sucks blood for food. Fleas are dangerous pests because they can carry the germs that cause plague and typhus. They get the disease germs by biting infected rats and other rodents. The fleas may pass on the disease when they bite another animal. See **Bubonic plague; Typhus.**

A flea has flat sides and a head much smaller than the rest of the body. The flea's shape and its strong, spiny legs help it glide quickly and easily through the hairs or feathers of its host. Fleas puncture the skin with their beaks to get blood.

Fleas live on human beings, cats, dogs, rats, birds, horses, poultry, rabbits, and many wild animals. A few kinds live only on certain types of animals. But most kinds pass readily from animal to human beings and from animal to animal. They leave the host as soon as it dies because they must have blood for food.

Common European flea

Fleas are strong and have great leaping ability for their size. Scientists have found that the flea that lives on people can jump more than 30 centimetres. Fleas can be made to perform tricks such as pulling tiny wagons. *Flea circuses* feature troupes of fleas that have been "trained" to do such tricks.

Kinds of fleas. The common *European,* or *human, flea* is about 3 millimetres long. It is found in the folds of clothing and may live for a year or more. It drops its eggs about the house instead of attaching them to clothing. The larvae look like tiny maggots. When they become adults, they seek a host. Some individuals attract fleas more than others do, and some become sensitive to the bites. The skin around the bite becomes inflamed in such people.

The *chigoe,* another kind of flea, is native to South America. But is has spread to Africa and many temperate regions. The female chigoe burrows into the skin of its host to lay eggs. These insects cause ulcers to form on the skin. The flea must be removed before the ulcer will heal.

Rat, cat, and dog fleas also may be serious pests. They lay many tiny oval white eggs on the animals or in their sleeping places. When the eggs hatch, the larvae crawl into bedding and into cracks in the floor. They spin their cocoons in dust and appear as adults about two weeks later.

Controlling fleas. Cleanliness and proper care of pets are the best ways to protect them against fleas. Dogs that have fleas should be scrubbed with soaps that contain an appropriate insecticide. Periodically treating pets with such soaps kills the insects. Owners of pets can guard against fleas by changing their pets' bedding frequently. The owners can destroy the larvae by spraying or dusting the pets' quarters with an insecticide.

Scientific classification. Fleas make up the order Siphonaptera. The common European, or human, flea is a member of the human flea family, Pulicidae. It is classified as *Pulex irritans.* The chigoe is *Tunga penetrans.*

Fleabane, also known by its scientific name *Erigeron* is the name of over 200 kinds of plants of the daisy family. The plants are found worldwide, with most species in North America. Many are grown in gardens for their colourful flowers. The flowers resemble those of asters. The central yellow *disc flowers* are surrounded by larger *ray flowers,* often orange-yellow, pink, or purple. Fleabanes grow best in moist, well-drained soil, in a sunny position.

Fleabane gets its name from the fact that people once thought the plant could drive away fleas. Canada fleabane is indeed a medicinal plant. It is picked while still in flower, and carefully dried. It is sold in herbalists as

The garden fleabane shown above has delicate violet flowers and often grows in clusters.

the drug *erigeron* used to treat diarrhoea and *dropsy* (the abnormal accumulation of body fluids).

Scientific classification. Fleabanes belong to the daisy family Compositae (Asteraceae). Canada fleabane is *Conyza canadensis.*

See also **Aster; Daisy.**

Flecker, James Elroy (1884-1915), was a British poet and dramatist. Much of his work displays a romantic interest in the ancient East. His best-known poems are "The Golden Journey to Samarkand" and "The Old Ships." His book *Collected Poems* was published in 1916. In 1923, his play *Hassan* was performed in London and was a great success. Flecker was born at Lewisham, in London, and educated at Oxford and Cambridge universities. He entered the consular service and spent much time in Turkey. He died in Switzerland.

Fleet Prison, an historic London jail, took its name from its location near Fleet stream. As early as the 1100's, it was the king's prison. In the 1500's and 1600's, it housed Puritans and victims of the Court of the Star Chamber (see **Star Chamber**). Later, it was a debtor's prison. In the 1700's, it became noted for cruelty. From the early 1600's until 1753, members of the clergy performed secret marriages in the prison. These ceremonies were called "Fleet marriages." The prison was abandoned in 1842, and it was later torn down.

Fleet Street is the London street that is identified with the national press of the United Kingdom (UK). At one time, most of the UK's national newspapers had their offices in or near Fleet Street. During the 1980's, when new technology replaced old methods of production, all national newspapers moved to new premises outside the Fleet Street area. However, a journalist working on a national newspaper is still said to be a *Fleet Street journalist.* Nearly all the national daily newspapers have their head offices in east London, generally to the east of Fleet Street. These papers include the *Daily Express, Daily Mirror, The Daily Telegraph, The Independent, Morning Star, The Sun,* and *The Times.* Some national papers, such as *The Guardian* and *The Daily Star,* have their editorial offices in east London, but are printed outside London.

Fleet Street itself runs between the Strand in the west and Ludgate Circus in the east. It lies in the City of London. The street is named after the Fleet, a river that flows south from Hampstead into the Thames. The river was covered over in 1765. Fleet Street has been associated with printing since the early 1500's.

Fleming, Sir Alexander (1881-1955), was a British bacteriologist at St. Mary's Hospital, part of the University of London. In 1928, he discovered the germ-killing power of the green mould, *Penicillium notatum,* from which the life-saving antibiotic, penicillin, was first purified (see **Antibiotic; Penicillin**). For his discovery, Fleming shared the 1945 Nobel Prize for medicine with British scientists Sir Howard Florey and Ernst B. Chain (see **Florey, Lord; Chain, Ernst Boris**).

The discovery and development of penicillin opened a new era for medicine, and World War II (1939-1945) provided an opportune field trial for the drug. Fleming discovered penicillin accidentally when he saw that a bit of mould growing in a culture plate in his laboratory had destroyed bacteria around it. Fleming also discovered lysozyme, a substance that is found in human tears. Even when diluted, this agent can dissolve certain germs.

Sir Alexander Fleming

Fleming was born on a farm near Darvel, Scotland. He attended St. Mary's Medical School in London.

Fleming, Ian Lancaster (1908-1964), an English novelist, became one of the most popular authors of the mid-1900's. He won fame for his creation of James Bond, a British secret service agent who attracts both beautiful women and villains in his series of fantastic adventures. The sophisticated Bond is also known by the code name *007.* Agents who use a double-0 code number are licensed to kill at their discretion.

Bond first appeared in *Casino Royale* (1953) and then in 11 other novels and two collections of short stories. The books attracted many types of readers. *Diamonds Are Forever* (1956) was a favourite of the more sophisticated readers, while *Doctor No* (1958) had a general appeal like the thrillers of the 1800's. A popular series of films based on the Bond novels helped spread the character's fame. Fleming also wrote *Chitty Chitty Bang Bang* (1964), a children's story about an old racing car that could fly. After Fleming's death, the Bond series was continued by English author John Gardner.

Fleming was born in London. During World War II (1939-1945), he did espionage work as the personal assistant to the director of British Naval Intelligence.

Fleming, Sir John Ambrose (1849-1945), a British electrical engineer, won fame for his invention of the thermionic radio valve. He sealed two wires inside a glass tube from which the air had been extracted. When one wire was heated, he noticed that an electric current could pass in one direction through the device but not in the other. The tube was the first *diode* (two-electrode valve). This tube, which came to be called the *Fleming*

valve, could detect wireless waves. The *triode*, another type of vacuum tube, was later developed by the American inventor Lee de Forest.

Fleming was born in Lancaster, England and was educated at London and Cambridge universities. He was associated at one time with Guglielmo Marconi (see **Marconi, Guglielmo**). He also worked with James Dewar, studying electrical resistance at low temperatures. Fleming developed electric lighting. He was an authority on *photometry* (the measurement of light).

Fleming, Sir Sandford (1827-1915), a Canadian civil engineer, built the Intercolonial Railway across Canada and made surveys for the main line of the Canadian Pacific Railway (now CP Rail). After 1876, he played a prominent role in establishing standard time zones (see **Standard time**). He proposed the use of the 24-hour system of keeping time. He also persuaded the Canadian, Australian, and British governments to cooperate in laying the Pacific cable between Australia and Vancouver in 1902, in an attempt to have a system of communication connecting the entire British Empire.

Fleming was born in Kirkcaldy, Scotland. He moved to Canada when he was 18. He joined the engineering staff of the old Northern Railway, and in 1855 became its chief engineer. He played an important role in railway development for all of Upper Canada. An advocate of transcontinental railways, he became engineer in chief of the government railways and a director of the Canadian Pacific Railway. He also paid the expense of locating a railway line in Newfoundland, Canada. He retired from active engineering in 1880.

Fleming was also interested in political affairs. He served as chancellor of Queen's University at Kingston, Ontario, Canada, from 1880 to 1915.

Fleming valve. See **Vacuum tube.**

Flemings are a group of people who live in northern Belgium. The region they inhabit is called Flanders. It consists of the provinces of Antwerp, East Flanders, West Flanders, Limburg, and the northern half of Brabant (see **Belgium** [political map]). Historically, Flanders had different boundaries and included parts of France and the Netherlands. The Flemings make up about 55 per cent of the Belgian population.

The Flemings are descended from the Franks, Germanic tribes who invaded Flanders in the A.D. 400's. This invasion forced the Celtic people in the area to move south. The Celts became the ancestors of the Walloons, who now live in an area of southern Belgium called Wallonia.

During the Middle Ages, the Flemings dominated European trade. Agriculture, fishing, and textiles also became thriving industries in Flanders. Between the 1400's and 1600's, the region produced some of the world's greatest painters, including Jan van Eyck, Pieter Bruegel the Elder, and Peter Paul Rubens.

Language differences have long been a source of conflict between the Flemings and the Walloons. The Flemings speak Dutch, and the Walloons speak French. When Belgium gained independence in 1830, French became its only official language.

Many Flemings protested about the domination of Belgium by French speakers. Dutch finally gained official recognition in the late 1800's. But the conflicts between the Flemings and the Walloons continued.

The Belgian government and most businesses now use both French and Dutch. Flemings have also won the right to schools that teach in Dutch. In 1980 the Belgian government granted limited self-rule to Flanders and Wallonia.

See also **Belgium** (People); **Flanders; Walloons.**

Flemish language. See **Belgium** (Languages).

Flemish literature. See **Belgium** (The arts).

Flesh is the name given to the soft tissues or parts of the body of human beings and of most animals with backbones. It is made up chiefly of muscle and connective tissue, but also includes some fat. The flesh is the meaty part of the body which surrounds the skeleton and body cavity. It does not include the organs in the body cavity or the bony and liquid tissues of the body. Animal flesh, or meat, is high in essential nutrients such as fat, protein, and minerals. The word *flesh* also refers to the pulpy parts of fruit and vegetables.

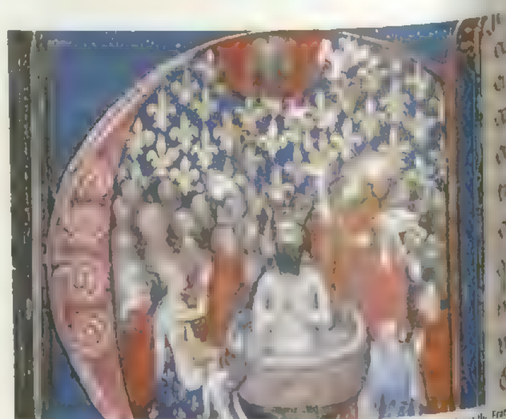
Flesh-eating animal. See **Carnivore.**

Flesh-eating plant. See **Insectivorous plant.**

Fletcher, John (1579-1625), was an English playwright. For many years, Fletcher's plays were as highly praised as Shakespeare's and Ben Jonson's. Fletcher wrote many kinds of drama, but his fame centres on his skilfully theatrical tragicomedies and such comedies of manners as *The Wild Goose-Chase* (1621). Like similar Restoration plays which followed, this play appealed to a pleasure-loving, sophisticated upper-class audience.

Fletcher was born in Sussex, England. His success began with his famous collaboration with Francis Beaumont (about 1608-1613). But Fletcher wrote some plays independently before, and many after, this association. Many of the so-called "Beaumont and Fletcher" plays belong solely to Fletcher or to Fletcher working with others (see **Beaumont, Francis**). Shakespeare probably wrote *The Two Noble Kinsmen* and *Henry VIII* with Fletcher.

Fleur-de-lis is a French name that literally means *flower of the lily*, but actually refers to the iris. The kings of France used an irislike design in heraldry. Some historians think this design originally represented an iris. Other historians believe the iris was once called a lily, and so the design was called *flower of the lily*. Others claim that the name originally meant *flower of Louis*.



Detail of an illuminated French manuscript (1400's); Musée Condé, Chantilly, France

The fleur-de-lis is an irislike design used in heraldry. Fleurs-de-lis were often associated with French royalty.

According to legend, Clovis I used the fleur-de-lis in the early 500's after an angel gave him an iris for accepting Christianity. *Clovis* is an early form of *Louis.* King Louis VI, who reigned from 1108 to 1137, was the first French king to use fleurs-de-lis in his coat of arms.

See also **Heraldry; Iris** (picture); **Flag** (picture: Historical flags of the world).

Flight. See **Aeroplane** (How an aeroplane flies); **Bird** (How birds move).

Flightless bird. See **Bird** (Birds of Australia and New Zealand; How birds move).

Flinders, Matthew (1774-1814), was a British navigator who charted and explored large areas of the Australian coastline. With the British explorer George Bass, Flinders sailed around Van Diemen's Land (now Tasmania) and proved that it was an island. Flinders also showed that there was no strait through the centre of Australia, as some people believed. He was also one of the first people to sail right around Australia, surveying much of the uncharted coastline.

Early life. Flinders was born in Donington, Lincolnshire, England. His father, a surgeon, wanted him to study medicine. But Daniel Defoe's book *Robinson Crusoe,* about a sailor marooned on a desert island, fired Flinders with the desire to go to sea and become an explorer. Flinders worked as an officer's servant on board the warship *Alert* in 1789. In 1791, he sailed through the Pacific Ocean to the West Indies with Captain Bligh. Flinders took part in the British victory over the French off Brest on June 1, 1794, on board the *Bellerophon.* He met Bass, a navy surgeon, on board the *Reliance* on its voyage to Australia.

Voyages of the *Tom Thumb.* After Bass and Flinders reached Sydney, in 1795, they set out to explore in the *Tom Thumb,* a small sailing boat 2.4 metres long and 1.5 metres wide. They sailed down the coast and explored Botany Bay and the George's River, which flows into it. In 1796, they set out in a larger boat, also called the *Tom Thumb.* They entered Port Hacking and sailed past the present site of Wollongong until they reached Lake Illawarra.

The brig *Investigator* conveyed Flinders around the Australian continent, despite the ship's dangerously rotten condition.

On this journey, Bass and Flinders met some Aborigines on the shore. They were afraid that the Aborigines would attack them. Flinders amused the Aborigines by cutting their hair. This device worked so well that afterward Flinders tried to treat the Aborigines with kindness and good humour.

Voyage around Van Diemen's Land. Later, in 1797, while Flinders was away in Cape Town, South Africa, Bass made a voyage in a whaling boat into what is now called *Bass Strait.* He suspected that a strait existed there. But he could not be sure, because he did not sail right through it. Flinders, who made a voyage to the Furneaux Islands off the coast of Tasmania, in 1797, also suspected that Van Diemen's Land was an island.

In 1798, Flinders and Bass set out to test their theories in the *Norfolk,* a small sloop of 25 metric tons. They passed through the strait between Van Diemen's Land and the mainland. This strait was later named after Bass. They sailed around Van Diemen's Land and proved that it was an island. The discovery of Bass Strait was important, since it shortened the voyage to and from England.

Voyage around Australia. Flinders returned to Britain in 1800. The naturalist Sir Joseph Banks introduced him to Lord Spencer, the First Lord of the Admiralty. Lord Spencer agreed to give Flinders command of the 339-metric ton brig *Investigator* to find out whether eastern and western Australia were separated by a large strait. Flinders married in Britain, but had to leave his wife, Anne, behind when he left in July 1801.

Flinders had *Investigator* repaired at the Cape of Good Hope. Then he sailed to Cape Leeuwin. He began his voyage along the southern coast of Australia. He explored Spencer Gulf, Gulf St. Vincent, and Kangaroo Island. Later, he met the French explorer Nicolas Baudin. Flinders called the place of their meeting *Encounter Bay.* He sailed on to Bass Strait and entered Port Phillip Bay. He landed in Sydney on May 8, 1802.

Matthew Flinders sailed around Australia in 1801, 1802, and 1803. He surveyed the southern coast, naming Spencer Gulf, Kangaroo Island, and Encounter Bay.

After taking on fresh stores and refitting his ship, Flinders sailed north to Cape York and through the dangerous Torres Strait. He then began to survey the coast of the Gulf of Carpentaria. Flinders found that his ship was in a dangerously rotten condition. He decided to complete the journey around Australia's coastline as quickly as possible. He reached Sydney again on July 9, 1803. *Investigator* was declared unfit to sail any farther.

Voyage back to Britain. Flinders set out for Britain as a passenger on the ship *Porpoise*. This ship attempted to sail to India through Torres Strait and was wrecked on a coral reef. Flinders returned to Sydney in an open boat. He set out again on Sept. 21, 1803, in command of the small 26-metric ton schooner *Cumberland*. He called at Mauritius. Britain and France were still at war. The French governor, General Decaen, imprisoned Flinders as a spy. The years of imprisonment, from 1803 to 1810, broke Flinders' spirit. When he was finally released, he was in poor health. He spent the last years of his life writing his book, *A Voyage to Terra Australis*. He died the day his book was published.

See also **Australia, History of; Bass, George; Baudin, Nicolas; Investigator.**

Flinders Island is the largest of the Furneaux group, in Bass Strait, off the northeastern coast of Tasmania. For location, see **Tasmania** (political map). The island is about 80 kilometres long and is between 13 and 24 kilometres wide. It has a population of about 905. The island's industries include farming, fishing, tourism, and exporting mutton birds. Whitemark is the largest town.

Flinders Range, in South Australia, stretches northward from Port Augusta to beyond Leigh Creek. The whole region lies more than 150 metres above sea level. St. Mary's Peak, on the northern edge of the Wilpena Pound, rises in height to nearly 1,200 metres above sea level. Wind and water have eroded the reddish rocks of the ranges, giving them sharp outlines. For location, see **South Australia** (map).

Flinders Range in South Australia lies in the centre of a scenic region which attracts many tourists.

Flint is a hard mineral that ranges in colour from brown to dark grey to black. It is a form of *chalcedony* that consists of tiny crystals of quartz with extremely small pores (see **Chalcedony**). In most cases, flint occurs as small masses embedded in such rocks as chalk or limestone. Lighter coloured deposits that occur as continuous layers are called *chert*.

Flint is formed by chemical action on minerals that contain a compound of silicon and oxygen called *silica*. Water dissolves the silica out of the minerals to produce a substance that resembles opal. The water in the substance then filters out, leaving flint.

Most flint is so even grained that it can be chipped into smooth, curved flakes. In prehistoric times, people fashioned flint into sharp tools and weapons, such as knives, spears, and arrowheads. Later, people discovered that striking flint against iron or steel produces a spark, and so used flint to start fires. The flintlock firearms that were manufactured from the 1600's to the mid-1800's made use of this property.

Flintlock was a firing mechanism used in pistols, muskets, and other firearms from about 1620 to the mid-1800's. Flintlock weapons had a piece of flint clamped in a piece called a *cock*. When the trigger was pulled, the cock snapped forward and the flint struck a piece of

A flintlock pistol was effective only at close range.

steel on a pivot, creating sparks. At the same time, a small pan filled with gunpowder was exposed. The sparks caused the gunpowder to explode and ignite the main charge in the barrel. Flintlocks could be *half-cocked*—that is, in a safety position—or *fully cocked* and ready for firing. Flintlock weapons were eventually replaced by firearms that used percussion caps.

See also **Firearm; Musket.**

Flintshire, in northeastern Wales, was the smallest Welsh county. In 1974, it became part of the new county of Clwyd. See **Clwyd; County.**

Flipper. See Animal (Bodies: Wings and fins); **Seal; Whale** (Body shape).

Flock. See **Animal** (Animals that live together).

Flodden Field, Battle of. See Scotland, History of (The Renaissance kings).

Floe. See **Iceberg.**

Flood is a body of water that covers normally dry land. Most floods are harmful. They may destroy homes and other property and even carry off the topsoil, leaving the land barren. When people are not prepared, sudden and violent floods may bring huge losses. Rivers, lakes, or seas may flood the land. River floods are more common, though lake and seacoast floods can be more serious. But sometimes floods may be helpful. For example,

Floodwaters can cause great damage. They have often destroyed entire communities. Floods usually occur in the spring, when melting snow and heavy rains combine to raise the level of rivers above their banks.

the yearly floods of the Nile River built up the plains of Egypt and made the Nile Valley one of the most fertile regions in the world. These floods brought fertile soil from lands far to the south and deposited the soil on the Egyptian plains.

River floods. Most rivers overflow their normal channels about once every two years. When a river overflows land where people live, it causes a flood. When a river overflows land where people do not live, it is said to be *in flood.*

Common causes of river floods include too much rain at one time and the sudden melting of snow and ice. Under such conditions, rivers may receive more than 10 times as much water as their beds can hold. Heavy rains produce *flash floods* if the rains cause small rivers or streams to rise suddenly and overflow. For example, in 1952, 230 millimetres of rain fell in 24 hours on the upper valleys of the East and West Lyn rivers in Devon, England. The West Lyn river burst its banks and a torrent swept through the town of Lynmouth, killing 23 people and making about 1,000 people homeless. Most flash floods occur in mountainous areas. They also occur in deserts, when a rare but violent thunderstorm turns *wadis* (normally dry watercourses) into raging torrents.

Many major rivers are famous for great floods. The Chinese call the Huang He (Yellow River) "China's sorrow" because floods have caused so much destruction. The worst floods occurred in 1887, when nearly a million people died. Disastrous floods have also occurred along the Mississippi River and its tributaries in the United States. For example, in 1937, the Ohio and Mississippi valleys experienced floods that killed more than 135 people and left about a million people homeless. In 1993, heavy rains in the American Midwest for about two months resulted in flooding along the upper Mississippi and Missouri river systems. The floods damaged over 10 billion U.S. dollars worth of property and forced about 74,000 people from their homes. In 1972, heavy rains in the states of New York and Pennsylvania caused rivers to overflow. The resulting floods caused about 3 billion U.S. dollars worth of damage and left more than 15,000 people without homes.

One of the worst floods in Indian history occurred in 1840 when an earthquake occurred in the upper Indus valley. A landslide created a natural rock dam in the valley. A lake formed behind this dam, reaching about 60 kilometres in length and more than 300 metres in depth. When the dam broke, a torrent surged down the Indus valley causing disastrous floods and great loss of life.

Australia's worst flood based on loss of life occurred in June 1852, when 89 people out of a population of 250 were drowned in Gundagai, New South Wales. In December 1916, a fast-rising flood swept through the low-lying areas of Clermont, Queensland, drowning 61 people. In autumn 1975, storms and prolonged rainfall caused flooding in New South Wales and Victoria. Hundreds of homes were damaged or demolished.

Seacoast floods. Most floods from the sea result from hurricanes or other powerful storms that drive water against harbours and push waves far inland. In 1970, a cyclone and a tidal wave in the Bay of Bengal, a part of the Indian Ocean, caused the greatest sea flood disaster in history. Huge waves struck the coast of Bangladesh and killed about 266,000 people. The flood also destroyed the cattle, crops, and homes of millions of other victims.

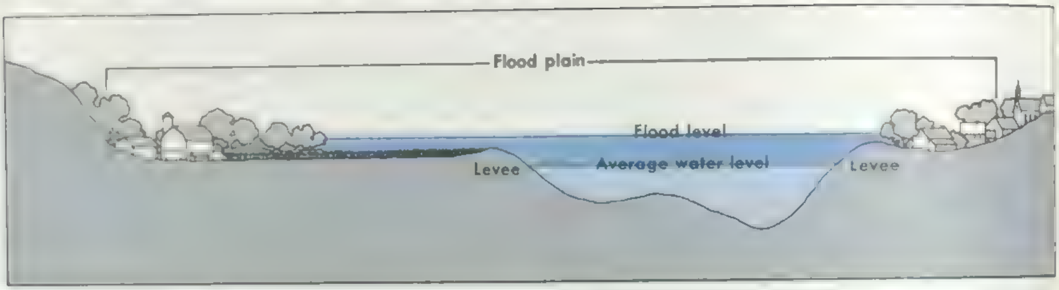
Depressions (regions of low air pressure) cause coastal flooding in western Europe. Sometimes, when depressions are over the North Sea, a combination of strong winds and high tides whip up the water into "hump" causing high *surge* tides along the coast. Such a storm in 1953 caused waves that breached the *dykes* (sea walls) of the Netherlands, flooding more than four per cent of the country. More flood damage occurred on the east coast of England and in the Thames estuary.

The coasts of southeastern England, including London on the Thames estuary, are especially vulnerable to floods, because geologists estimate that this region is sinking at a rate of 30 centimetres every 100 years. This factor, combined with a possible rise in the sea level caused by global warming, due to the "greenhouse effect," makes London especially vulnerable to surge tides.

Earthquakes and volcanoes also produce high waves that cause coastal floods. A sea wave caused by an earthquake or a volcanic eruption is called a *tsunami.* For example, in 1883, the volcano Krakatoa in Sunda Strait, west of Java, erupted and caused tsunamis up to 35 metres high. About 30,000 people were killed and one ship was carried 2.5 kilometres inland.

Other floods. Storms and high winds also cause floods along lakeshores. Some lakeshore floods occur when water moves suddenly from side to side in rhythm. Such a movement of the water of a lake is called a *seiche.* The failure of artificial structures, such as dams, has caused a number of floods. In 1963, the Vaiont Dam in Italy collapsed, and the resulting flood killed about 1,800 people.

Flood control. Flooding has been made worse in many areas by human activity, especially deforestation and overintensive farming. On exposed land, rain, in-



A flood occurs when a river rises above its normal level and overflows its banks. People have built *levees* along some rivers to hold back the high water, but a river may overflow even such barriers. Floodwaters generally cover only a river's *flood plain*, the nearby low-lying land. But sometimes extremely high waters flood a much larger area.

stead of being absorbed by the soil and plants, tends to run across the surface directly into rivers, rapidly increasing their volume and sometimes causing flash floods. Over a few years, eroded soil that is washed into rivers piles up on river beds, raising the level of the water. Flood control in such regions involves building dams to store water, and planting trees on eroded slopes. It also involves dredging river beds and strengthening the *levees* (raised banks along rivers).

Along coasts, engineers build dykes, flood walls and hurricane barriers to keep seawater off the land. For example, in the Netherlands, where two-fifths of the land is below sea level, the Dutch have built a huge system of dykes to hold back the sea.

Most coastal towns have strong stone sea walls to prevent flooding at high tide and many have wooden barriers called *groynes* to halt the erosion of beaches. In places, *dunes* (hillocks of sand) are planted with grass and trees. The plants anchor the sand and so help to check tidal flooding.

Flood control is often achieved through such temporary measures as sandbagging. These workers are placing sandbags along the shore of Lake Ontario to prevent its steadily rising waters from overflowing. Sandbagging is also used to control lake flooding caused by storms and high winds.

Some estuaries that experience surge tides are protected by movable barriers. The Thames flood barrier at Woolwich, London, consists of a series of movable steel gates built to form a continuous wall across the Thames. The gates *pivot* (turn) between concrete piers. When not in use, they lie concealed in the riverbed so that they do not hold up shipping. If the surge tide alarm is given, the gates can be turned upright to keep the water from surging upriver and flooding London. The barrier was completed in 1982.

Reducing flood losses. Engineers work not only to control floods, but also to reduce flood losses. A programme to decrease such losses includes regulations to control permanent construction on the *flood plain* (land that gets flooded) and to make buildings waterproof. Other programmes aim to help the victims of a flood by improving methods to warn and evacuate people from flood plains and to provide better insurance and relief aid.

Scientists can identify areas that are liable to be flooded. In some countries, such as the United States, the government has required that small strips of land along waterways be left vacant. Such land is called a *floodway*. Many communities establish wider areas along floodways for use as farmland or parkland.

Permanent buildings can be located on a flood plain and withstand flood damage. The technique of keeping water out of buildings is called *flood-proofing*. It involves raising buildings off the ground or using waterproof construction materials.

Weather forecasters also play an important part in reducing flood losses, by issuing storm and flood warnings. In this way, they hope to greatly reduce loss of life and to lower property damage. However, major disasters still occur and international appeals are sometimes necessary to help flood victims.

Related articles in ***World Book*** include:

Conservation	Disaster
Dam	Huang He

Flooring is the general name given to all materials used to cover floors. The most common floorings are wood, concrete, stone, and tile. The main purpose of flooring is to keep rooms clean, dry, and warm.

The first floors were probably only the levelled soil over which the houses were built. For hundreds of years, the houses of poor people continued to have only earth floors. But ancient peoples used floors of stone

and baked clay in large public buildings and temples. The Greeks used marble in their floors. The Romans learned how to make cement. Stone was the most common flooring of public buildings and churches during the Middle Ages. In the 1500's, the Venetians developed *terrazzo,* one of the oldest types of flooring. They made it from granulated marble mixed with cement. Wood was first used as flooring in the Middle Ages. *Parquet* floors of different coloured woods arranged in designs decorated early palaces.

See also **Interior decoration** (Choosing patterns and textures).

Flora is the name given to the plant life of a particular part of the world or period of time. It corresponds to the word *fauna,* which is the term for the animal life of a certain place or time. The term *flora* is taken from the name of the Roman goddess of flowers and spring.

Florence (pop. 403,294) is an Italian city that became famous as the birthplace of the Renaissance. Its name in Italian is Firenze. During the Renaissance, from about 1300 to 1600, some of the greatest painters, sculptors, and writers in history lived and worked in Florence.

The city lies on both banks of the Arno River in central Italy, about 100 kilometres east of the Ligurian Sea. For location, see **Italy** (political map). Florence is the capital of both the province of Florence and the region of Tuscany.

Such great artists as Leonardo da Vinci, Fra Angelico, Giotto, and Michelangelo produced many of Florence's magnificent paintings and sculptures. Great writers who lived in the city included Giovanni Boccaccio, Dante, and Petrarch. The architect Filippo Brunelleschi and the political analyst Niccolò Machiavelli were born in Florence, and the astronomer and physicist Galileo did some of his work there.

Today, about a million tourists visit Florence each year to see its art galleries, churches, and museums. Florentines consider Michelangelo's marble statue, *David,* which is on display in one of the city's art galleries, as the symbol of the artistic spirit of the city.

The city covers about 100 square kilometres in the middle of a rich farming area. The oldest part of Florence lies in a small area divided by the Arno. Most of the city's famous buildings are on the right bank, north of the river. A broad public square called the Piazza della Signoria is a major public gathering spot and tourist attraction on the right bank. Towering over the piazza is the Palazzo Vecchio, or Palazzo della Signoria, a palace that has been the centre of local government since the Middle Ages. Many old, impressive churches stand on the right bank of the Arno. The Cathedral of Florence, called the Duomo, is in the Piazza del Duomo. The eight-sided Baptistery, with its beautifully decorated bronze doors by Lorenzo Ghiberti and Andrea Pisano, is part of this piazza. The piazza also features a *campanile* (bell tower) built by Giotto and Pisano.

The tombs of Galileo, Machiavelli, Michelangelo, and other famous Florentines are in the Church of Santa Croce. This church also has frescoes by Giotto. The Church of San Marco and an adjacent museum display a collection of paintings by Fra Angelico and other artists of the 1400's. The chapel of the Church of San Lorenzo has the large stone figures carved by Michelangelo for the tombs of the powerful Medici family.

Many outstanding art galleries and museums are also on the right bank. The famous Uffizi Palace, which once housed government offices, is now an art gallery. It owns one of the world's finest collections of paintings and statues (see **Uffizi Palace**). The National Museum of the Bargello exhibits many masterpieces of Renaissance sculpture. The Galleria dell'Accademia displays medieval and Renaissance sculpture, including Michelangelo's *David.*

Florence's most elegant shopping area lies along the Via Tornabuoni, a street in the western part of the old section of the city. Some shops on this street display the kinds of clothing and leather goods that have made Florence famous for fashions.

Six bridges connect the right bank with the Oltrarno, the section of Florence south of the river. Goldsmiths and jewellers line one of these bridges, the Ponte Vecchio, which was built in 1345. The other bridges replaced those destroyed during World War II (1939-1945). The Ponte Santa Trinita is an exact reconstruction of the original bridge, which had stood since 1570.

The Oltrarno includes many antique, silver, and woodcarving shops, but its most famous attraction is the Pitti Palace. This palace—the largest in Florence—was begun in 1458 as a home for Luca Pitti, a wealthy merchant. It now displays an excellent collection of paintings (see **Pitti Palace**). The Boboli Gardens, behind the palace, are among the most beautiful gardens in Italy.

Florence lies on the banks of the Arno River, in central Italy. The city became famous as the birthplace of the Renaissance.

Modern apartment buildings stand in Florence's suburbs, which have developed since the 1950's. Industry is concentrated north of the city.

The people. Almost all Florentines are of Italian descent. They speak Italian and belong to the Roman Catholic Church

Most families in the oldest part of the city live in old stone buildings that lack central heating. Large numbers of families in the suburbs make their homes in modern apartment buildings.

Florentines, like most Italians, eat their largest meal at lunchtime. This meal may include fruit, meat, vegetables, and one of several kinds of noodles called *pasta*, such as spaghetti or ravioli. Other favourites of the people include Chianti wine, steak, cheese, and olives.

Florence has many public markets. Shoppers meet every morning in the market places and chat as they shop. The Mercato Nuovo, a market square in the heart of Florence, attracts thousands of tourists daily.

Education and cultural life. Florence is the home of the University of Florence and several research institutes. The Academy of Fine Arts and the Luigi Cherubini Conservatory of Music are also in the city. Operas are presented at the Teatro Comunale and the Teatro Verdi. Public libraries in Florence include the Laurenziana, the Marucelliana, the Riccardiana, and one of Italy's two national central libraries.

Economy. Florentines have made fine handicrafts since the days of the Renaissance. Many of the people make or sell such handicrafts as leather products, jewellery, mosaics, pottery, and articles made of straw. Tourism is an important economic activity of Florence.

Factories in the city produce clothing, drugs, foods, glass, and plastics. Florence is a major communications and railway centre of Italy.

History. The Etruscans, a tribe that migrated to Italy from Asia, built the first settlement in what is now Florence. They arrived there about 200 B.C., but their settlement was destroyed in 82 B.C. following a Roman civil war. In 59 B.C., the Roman ruler Julius Caesar established a colony on the Arno and named it Florentia. The name later became Florence.

Florence remained a small, unimportant town until about A.D. 1000. It then began to develop into a self-governing area called a *city-state*. Its population grew from perhaps 5,000 in A.D. 900 to about 30,000 in 1200.

The people of Florence developed new processes for refining wool, and the city gained importance for its woollen textiles. Florentine bankers became successful and brought much wealth to the city. The population reached about 100,000 in the early 1300's. Florence fought many wars during the 1300's and early 1400's, gaining and losing territory at various times.

During the 1300's, four Florentines introduced new styles of painting and writing that grew into great achievements of the Renaissance. Giotto painted pictures with realistic figures instead of stiff, formal subjects. In literature, Dante developed Italian as a literary language and Petrarch and Boccaccio renewed interest in the classics. For the next 300 years, Florence was a centre of one of the greatest periods of cultural achievement in history.

The wealthy Medici family gained control of Florence in the early 1400's. By that time, Florence had become a strong and almost independent city-state. It controlled part of what is now central Italy. The city achieved its greatest splendour under the most famous Medici, Lorenzo the Magnificent, who ruled from 1469 to 1492. Except for brief periods, members of the Medici family governed until 1737. During their rule, Florentine literature, theatre, and opera thrived in Florence and were imitated throughout Europe. See **Medici**.

Florence was the capital of Italy from 1865 to 1870, when the government moved to Rome. Many improvements were carried out in Florence during its period as the capital. For example, the tree-lined boulevards and large piazzas just outside the historical centre of Florence were built at that time.

The Ponte Vecchio (Old Bridge) spans the Arno River in Florence, Italy. Shops line both sides of the bridge, a historic landmark built in 1345.

Art treasures of Florence, Italy, include many statues in the Piazza della Signoria, a square in the heart of the city.

During World War II (1939-1945), several ancient palaces were destroyed during the fighting for Florence. But most of the city's art treasures escaped harm.

In 1966, a flood caused damage to books, manuscripts, valuable works of art, and museums and other buildings in Florence. Many countries aided in the restoration of the art works. Most of the paintings and manuscripts were saved, though some required years of careful work.

Florence has faced many problems resulting from a huge increase in the city's population. The number of Florentines has grown from about 96,000 in 1861 to more than 450,000 today. Municipal services, including electricity, have sometimes fallen short of providing enough for everyone. Pedestrians, including many tourists, and traffic crowded the narrow streets of the old section. In 1970, private cars were banned from the historic centre of the city.

See also **Architecture** (Renaissance; picture: The dome of the Cathedral of Florence); **Painting** (The Renaissance in Florence; pictures); **Renaissance** (The Italian Renaissance); **Savonarola, Girolamo; Sculpture** (Italian Renaissance; pictures).

Flores. See **Indonesia** (table: Chief islands).

Flores Island (pop. 4,367), famed for its abundant foliage, is the westernmost island of the Portuguese Azores. It covers 143 square kilometres. The main occupations are dairying and cattle raising. Santa Cruz is the chief town. See also **Azores.**

Florey, Lord (1898-1968), a British bacteriologist, helped develop with Ernst B. Chain the antibiotic penicillin (see **Antibiotic; Penicillin**). Sir Alexander Fleming discovered penicillin in 1928. Florey shared the 1945 Nobel Prize for medicine with Fleming and Chain (see **Fleming, Sir Alexander; Chain, Ernst Boris**). In 1940 and 1941, Florey's research team at Oxford isolated penicillin in relatively pure form, and tested it.

Howard Walter Florey was born in Adelaide, Australia. He studied at Adelaide University, and, as a Rhodes scholar, at Magdalen College, Oxford University. He was professor of pathology at Oxford University from 1935 to 1962.

Floriculture is the art, science, and business of growing and caring for ornamental plants. Some ornamental plants are grown for outdoor use, others for interior decoration and special occasions.

Growing and marketing cut flowers and decorative plants ranks as a large industry. In mild climates, people grow cut flowers and pot plants outdoors, even in winter. But in cold climates, such plants are grown in greenhouses that can be heated during cold weather. Growers can control the blossoming of flowers. For example, they can arrange to have poinsettias in bloom for Christmas.

Floriculturists control the blooming of flowers by various techniques developed through research. They also control blossoming by planting the flowers on certain dates, by removing the tips of the plants, and by regulating the temperature and the periods of darkness. Sometimes they artificially lengthen or shorten the amount of light the plant receives each day. Researchers in floriculture have developed long-stemmed carnations, thornless roses, and double snapdragons. Floriculturists work in nurseries, florists' shops, seed companies, public and private gardens, zoos, and environmental planning companies.

See also **Florist; Greenhouse; Hybrid.**

Florida is the southernmost state on the mainland of the United States. Its warm, sunny climate attracts many retired people and holiday makers. Popular seaside resorts in Florida include Clearwater, Daytona Beach, Fort Lauderdale, Key West, Miami Beach, Palm Beach, Panama City, and Sanibel Island. Tourists flock to Walt Disney World, an amusement park near Orlando, and to the Kennedy Space Center on Cape Canaveral.

Florida's population and economy are expanding rapidly. Especially fast-growing fields are banking, business services, and the manufacture of computers and other electronic equipment. Florida's farmers grow more than two-thirds of the U.S. crop of oranges and grapefruit.

Land. Florida is sometimes called the *Peninsula State* because it juts southward about 640 kilometres into the sea. The northwestern part of the state, known as the *panhandle,* extends along the Gulf of Mexico.

Florida is the southernmost state on the mainland of the United States.

Central Miami rises beyond the city's port, which handles passenger ships from many countries. Miami, Florida's second largest city, is a leading North American tourist centre.

The Atlantic Coastal Plain covers the entire eastern part of Florida. A narrow ribbon of sand bars, coral reefs, and islands lies in the Atlantic Ocean, just beyond the mainland. Long shallow lakes, lagoons, rivers, and bays lie between much of this ribbon and the mainland. Big Cypress Swamp and the Everglades cover most of southern Florida. The Everglades include more than 7,000 square kilometres of swampy grasslands. The Florida Keys make up the southernmost part of the state. These small islands curve southwestward for about 240 kilometres off the mainland from Miami.

The East Gulf Coastal Plain of Florida has two main sections. One covers the southwestern part of the peninsula. The other section curves around the northern edge of the Gulf of Mexico across the panhandle to Florida's western border.

The Florida Uplands comprises the northern half of the panhandle and a large area west of the Atlantic Coastal Plain. The uplands region is higher than Florida's other land regions. Lakes are common in the uplands. Pine forests grow in the northern section. Citrus groves thrive in the southern part.

Biscayne Bay, south of Miami, is the one major bay on the Atlantic coast. The most important bays along the western coast include Charlotte Harbor, San Carlos, Sarasota, and Tampa.

The St. Johns River is the longest river in the state, flowing for almost 450 kilometres. Lake Okeechobee is Florida's largest lake, covering about 1,750 square kilometres. It is the second-largest natural body of fresh water located wholly within the United States. Only Lake Michigan covers a larger area. About 30,000 shallow lakes lie throughout the central part of the state. Florida has 17 large springs and countless smaller ones. Many of the springs contain mineral waters.

Economy. Wholesale and retail trade form the leading economic activity in Florida. It employs 27 per cent of the state's workers. Retail trade is more important than wholesale trade in Florida. The most important types of retail establishments in the state are car dealerships and grocery stores. The wholesale trade of petroleum products and citrus fruit is significant in Florida.

Community, social, and personal services employ more than 25 per cent of the state's workers, in such activities as the operation of amusement parks and hotels, private schools and hospitals, and repair shops.

The finance, insurance, and property industries grew with the state's rapid population growth. The large numbers of retired people are an important source of investment funds for finance and insurance companies. Jacksonville and Miami are Florida's leading centres of banking and insurance.

The Miami-Ft. Lauderdale area, the state's leading manufacturing region, benefited from the growth of the federal government's defence programme. Aerospace equipment and military communication systems are leading manufactured products. Citrus fruit processing is also a major industry, in Florida. Other manufacturing centres include Tampa, Jacksonville, and Orlando.

Crops account for about 80 per cent of Florida's total farm income. Oranges are the leading farm product. Other citrus fruit grown in the state include grapefruits, limes, tangerines, tangelos, and temples.

Tomatoes are Florida's most important vegetable and second leading crop. Many northern U.S. states rely on Florida for fresh vegetables during cold months.

Sugar cane is another important crop in Florida, which is the leading U.S. state in sugar cane production. Florida ranks second to California in the production of greenhouse and nursery products. The state also produces about three-fourths of U.S. output of phosphate rock.

Florida is a leading commercial fishing state. Shrimp, lobsters, and scallops are the main catches.

Facts in brief

Population: 13,003,362.
Area: 151,939 km².
Climate: *Average July temperature*—27° C. *Average January temperature*—15° C.
Elevation: *Highest*—105 m. *Lowest*—sea level.
Largest cities: Jacksonville, Miami, Tampa, St. Petersburg.
Chief products: *Agriculture*—oranges, greenhouse and nursery products. *Manufacturing*—food products, electrical equipment, transportation equipment, printed materials. *Mining*—phosphate rock.

Miami International Airport handles much of the air passenger and air freight traffic to and from Latin America. Miami is often called the gateway to Latin America.

About 15 deepwater ports in Florida serve as ports of entry into the United States. Tampa is the main port. Many large freighters and cruise ships are based in Florida ports.

History. Burial mounds found along Florida's western coast show that Indians lived in the region at least as long as 10,000 years ago. About 10,000 Indians lived in the region when Europeans first reached its shores.

Spanish explorer Juan Ponce de León claimed the Florida peninsula for Spain in 1513. A group of *Huguenots* (French Protestants) established a colony on the St. Johns River in 1564. The next year, a group of 100 Spaniards founded St. Augustine, the first permanent European settlement in what is now the United States. The Spaniards massacred the French colony and ended French attempts to settle in eastern Florida.

Spaniards occupied Florida for the next 200 years. Meanwhile, English colonists established settlements to the north of Florida, and France started colonies to the west. In the mid-1700's, wars broke out between the two groups. Spain sided with France. In 1762, British forces captured Cuba. In 1763, Spain gave Florida to Britain in exchange for Cuba.

Spanish forces regained control of Florida during the American Revolution (1775-1783). The United States formally took control of Florida in 1821.

The U.S. Congress organized the Territory of Florida in 1822. Thousands of American settlers poured into the territory, but they had difficulty finding enough land for settlement. The Seminole Indians lived in some of the richest farmland. The U.S. government offered the Indians land in the Oklahoma territory, but many refused to leave their homes. The Second and Third Seminole Wars in the mid-1800's resulted in most of the tribe being wiped out or forced to resettle.

Florida was admitted to the Union as a slave state in 1845. On Jan. 10, 1861, Florida *seceded* (withdrew) from the Union. Tallahassee, Florida, and Austin, Texas, were the only Confederate state capitals that Union troops did not capture during the American Civil War (1861-1865). Florida was readmitted to the Union on June 25, 1868.

Florida developed rapidly during the 1880's. Geologists discovered large phosphate deposits. Swampland was drained. Railways led to the opening up of new land for development. Citrus groves were planted. Resort cities sprang up. People and money from northern states poured into Florida.

Reports of fantastic profits to be made on Florida property swept the U.S.A. during the early 1900's. By 1925, Florida's economy had become a swelling bubble of progress and prosperity. The bubble burst in 1926, when a severe depression hit Florida. The state had partly recovered by the late 1920's. Then, in 1929, the Great Depression struck the United States. Federal and state welfare measures helped Florida during the Depression years.

Florida's location along the Atlantic Ocean and near the Panama Canal made the state important for the defence of the Western Hemisphere during World War II (1939-1945). Land, sea, and air bases were established in many parts of the state.

After the war, Florida's population grew tremendously. Tourism remained the leading source of income, but industrial expansion helped give the state a more balanced economy. In the 1950's, Cape Canaveral became a space and rocket centre.

In the early 1960's, after Cuba fell under Communist control, many Cubans fled to Florida. They settled mainly in Miami and Hialeah.

Like many other U.S. states, Florida faced serious racial problems during the 1960's. By the late 1960's, every county had integrated all or most of its public schools. Florida also began an ambitious programme to expand its facilities for higher education during the 1960's. It was partly designed to serve the future demands for personnel in the oceanographic and aerospace industries.

Florida grew rapidly during the 1970's and 1980's. After 1980, more than 100,000 Cuban and Haitian refugees settled in Florida. The state's spectacular growth, however, has also brought problems. The increasing population requires more homes, roads, schools, sewage and water treatment plants, and health and social services. Uncontrolled development has also led to growing concern for protecting Florida's environment.

See also **Everglades; Miami.**

Florida Keys are a group of small islands or reefs that are part of southern Florida, U.S.A. They stretch in a curved line about 240 kilometres long from Biscayne Bay southwest into the Gulf of Mexico. The word *keys* comes from the Spanish word, *cayo,* which means *small island.* The Keys are remarkable examples of coral formation. They attract a large tourist trade. Industries include sponge, cigar, and canning factories. Key West, farthest from the mainland, has the most important harbour. It is joined with the mainland by an overseas highway 206 kilometres long. See also **Florida; Key West.**

Florin is a type of coin first made in the Italian city of Florence in 1252. Made of pure gold, the florin weighed about 3.5 grams. Florins became popular for trade during the economic expansion of Europe from the 1200's to the 1400's. The coin's name comes from an Italian word meaning *little flower.* It refers to a lily, the symbol of Florence. A lily appears on one side of the coin. The other side has a figure of Saint John the Baptist, the guardian saint of Florence. Many European countries produced similar versions of the Florentine florin.

Florence stopped making florins in the early 1500's. In 1849, Great Britain issued its first silver florin. This coin was valued at a tenth of a pound. In 1971, Britain adopted a florin worth 10 new pence. The Netherlands also used silver florins.

Florist is a merchant who sells cut flowers and pot plants. A florist may also sell plant bulbs and seeds, potting soil, and various plant care products. Most florists employ a *floral designer,* who is specially trained in the art of arranging flowers. Others prepare floral arrangements themselves.

In the majority of florists' shops, the flowers and plants come from commercial greenhouses and nurseries. However, some florists have gardens or greenhouses in which they grow many or all of the plants they sell. Customers may buy flowers or plants at the shop or call the florist and order flowers to be delivered. Many florists belong to an association that forms a pool of

A florist's shop, such as the one shown above, features colourful displays of potted plants and cut flowers. A florist helps customers choose plants and flowers for various occasions.

In making a corsage, a florist uses a variety of tools and materials. The corsage shown above will consist of an orchid and such materials as ribbon, tape, and artificial leaves.

florists in various countries throughout the world. If a florist belonging to such an association receives an order for a delivery in another town or city, he or she sends the order to a member florist in that location. The order for a delivery may be transmitted either by telephone or by computer.

Special training is not required for a career as a florist. Many people prepare to become florists by studying *floriculture,* the science of growing and caring for ornamental plants. Courses that teach sales techniques and store management are also helpful. Some schools offer courses in floriculture. Many florists' shops have apprenticeship programmes.

See also **Floriculture; Flower; Greenhouse.**

Flotation process is used to separate valuable minerals from each other or from other minerals with which they are mixed. In this process, the material that contains the minerals is first crushed and ground to a fine powder. It is then put into a tank called a *flotation cell* that contains water and certain chemicals called *flotation reagents.* These chemicals form a water-repellent film around the particles of one of the minerals, but not around the others.

To separate the minerals, the liquid in the flotation cell is stirred and air is piped in. Air bubbles cling to the water-repellent particles, causing them to rise to the top and float. For collection, the bubbles carrying the minerals must be trapped in a froth on the surface. A frothing agent, such as pine oil or eucalyptus oil, is added to create the froth. The froth with the mineral-laden bubbles can then be skimmed off. The other minerals or materials remain in the liquid.

See also **Copper** (Milling).

Flotsam, jetsam, and lagan are terms used to describe goods in the sea. Goods found floating in the sea are called *flotsam.* The term applies to both goods cast from a vessel in distress and goods that float when a ship sinks. *Jetsam* is goods voluntarily cast overboard in an emergency, usually to lighten the vessel. Jetsam sinks and remains under water. *Lagan,* or *ligan,* is cargo that someone has sunk with the definite intention of recovering it later. The person usually ties a buoy to lagan to mark its location.

Flotsam, jetsam, and lagan are not abandoned or derelict property. That is, the owner or master of the ship does not intend to give up the goods permanently. The owner intends to recover the goods at some later date. Under maritime law, flotsam, jetsam, and lagan remain the property of their original owner, no matter how long they lie in the sea. The finder may only hold them for salvage, which is a legal reward the owner pays to the finder. Many courts rule that the owner must claim the goods within a year after someone else has recovered them.

See also **Salvage.**

Flounder is the name of a group of saltwater flatfish. Flounders live on the sandy and muddy bottoms of bays and along the shores of most seas. There are about 300 different types of flounders. The European flounder is found from the waters of northern Norway as far south as the Mediterranean, Adriatic and Black seas. It is abundant in the Baltic, where it is an important food fish. The starry flounder lives in the north Pacific ocean, from California and Alaska, in the U.S.A., to the Bering sea, Japan

The flounder is a saltwater flatfish. The starry flounder, *above,* is a popular game fish along the California coast of the U.S.A. This fish can be identified by the coloured bands on its fins. Its body is covered with sharp, thornlike spines in its skin.

and Korea. It is a popular game fish along the Californian coast.

The flounder has a greatly compressed body with both eyes on the same side of the head. The side of the flounder facing up takes on the colour of the bottom of the sea where the fish lives. The side toward the bottom is nearly white. When the flounder first hatches, it looks like a typical fish. After it grows to about 1.5 centimetres long, the body becomes flattened, and both eyes appear on one side of the head. Flounders have markings that blend with their surroundings. The fish can lie camouflaged on the seafloor. This makes it easier for them to catch the shrimp and small fish that form their basic diet. The dab, halibut, and plaice belong to a flounder family. Flounders are also closely related to soles and turbot (see **Sole**).

Scientific classification. Flounders belong to the flatfish order Pleuronectiformes. They may belong to one of four families: Bothidae, Citharidae, Pleuronectidae, or Scophthalmidae. The European flounder is *Platichthys flesus.* The starry flounder is *P. stellatus.*

See also **Flatfish; Halibut; Turbot; Fish** (picture: A flounder).

Flour is a powdery food made by grinding grain. Most flour is made from wheat and is used to bake bread. Other cereal grains that are ground into flour include barley, maize, millet, oats, rice, and rye. Flour is the basic ingredient of such foods as biscuits, cakes, macaroni, and pancakes.

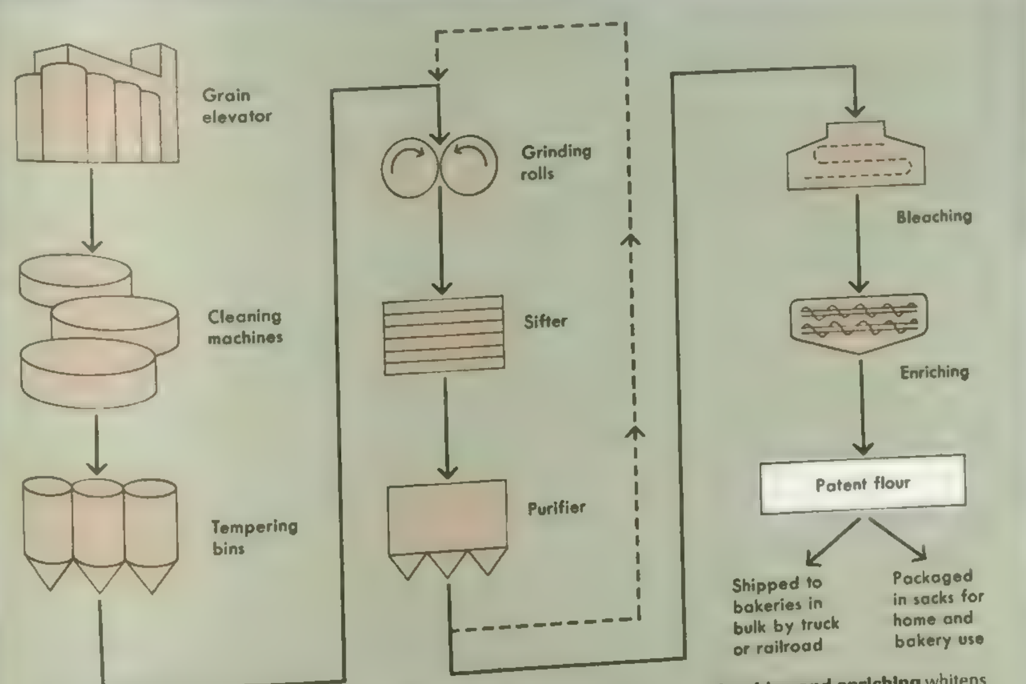
Bread ranks as the world's most widely eaten food, and people in many countries receive more than half their nourishment from foods made with flour.

Types of flour. White flour made from wheat accounts for most of the flour produced in industrial countries. There are three main types of white wheat flour: (1) bread flour, (2) cake flour, and (3) all-purpose flour. Bread flour is milled chiefly for commercial bakeries, though it is available in retail stores in some areas. Cake flour is made for commercial and home baking. All-purpose flour is used mainly at home.

The three types of flour differ primarily in their protein content. Bread flour may contain 11 per cent protein, and cake flour less than 8 per cent protein. All-purpose flour, which is a blend of bread flour and cake flour, has a protein content of about 10 per cent.

When the protein in wheat flour is moistened in dough, it forms a sticky substance called *gluten.* Bread flour dough has strong gluten, cake flour dough has weak gluten, and all-purpose flour dough has a blend of strong and weak glutens. Strong gluten works well with

How white flour is milled



Preparing the wheat for milling involves cleaning and *tempering* (moistening) the kernels. Wheat consists of a covering called the *bran,* an inner part called the *endosperm,* and a tiny new plant called the *germ.*

Grinding the wheat breaks up the kernels. Sifters and purifiers then separate the endosperm from the bran and the germ. The endosperm is repeatedly ground, sifted, and purified until it forms flour.

Bleaching and enriching whitens the flour and adds iron and vitamins. This high-quality flour, called *patent flour,* is loaded into trucks or railway wagons, or packaged in sacks. Mills sell it to bakeries and groceries.

Chemists test samples of bread made from flour from different varieties of wheat. Seeds from the varieties that produce high-quality bread are distributed to farmers for planting.

yeast to *leaven* bread, or make it rise. Weak gluten produces tender, crumbly baked goods, but it results in poor yeast-leavened bread. Therefore, bakers use bread flour for breads, and cake flour for pastries. All-purpose flour is used for such foods as biscuits, cakes, rolls, and homemade bread, and in sauces.

Bread flour is sometimes called *strong flour* because it forms strong gluten. This kind of flour is also known as *hard-wheat flour* because it comes from varieties of wheat that have hard kernels. Millers call cake flour *weak flour* because it forms weak gluten, or *soft-wheat flour* because it is produced from wheat that has soft kernels.

The term *speciality flours* is used for types of flour other than white wheat flour. They include rye flour, wholemeal flour, and *mixes.* Mixes consist of flour and other ingredients used to make various foods, such as cakes and pancakes.

How white flour is milled. Wheat kernels form the raw material for flour. They consist of a tough covering called the *bran,* a mellow inner part called the *endosperm,* and a tiny new wheat plant called the *germ.* To make white flour, millers separate the endosperm from the bran and germ and then grind the endosperm into flour.

Various cleaning machines first remove dirt, straw, and other impurities from the grain. Next, the wheat is *tempered* (moistened). The moisture makes the endosperm more mellow and the bran tougher.

The tempered wheat passes between a series of rough steel rollers that crush the endosperm into chunks. Pieces of bran and germ cling to the chunks of endosperm or form separate flakes. Then the crushed grain is sifted. The tiniest bits of endosperm, which have become flour, pass through the sifter into a bin. Larger particles collect in the sifter. Next, these larger particles are put into a machine called a *purifier.* There, currents of air blow flakes of bran away from the endosperm particles. The endosperm particles are then repeatedly ground between smooth rollers, sifted, and purified until they form flour. In most mills, about 70 per cent of the wheat eventually becomes flour. The rest is sold chiefly as livestock feed.

Newly milled flour is cream-coloured, but some mills bleach it to make it white. They may also add chemicals that strengthen the gluten. Some chemicals both bleach the flour and strengthen the gluten. Such treatments must be carefully controlled because the addition of too much of a chemical ruins the flour.

Wheat is rich in starch, protein, B vitamins, and such minerals as iron and phosphorus. But the vitamins and some of the minerals are chiefly in the bran and germ, which milling removes from white flour. Millers may enrich their product by adding iron and vitamins to white flour made for home use. Many bakeries in industrial countries use enriched flour, or they add vitamins and minerals to dough made with unenriched white flour.

The enriching of white flour has probably helped millions of people avoid malnutrition. Diseases caused by a lack of B vitamins were common in some industrial countries before the mid-1900's. Then, bakers and millers began enriching white-flour products. Today, few people in industrial countries suffer from those diseases.

History. People probably began to make crude flour between 15,000 B.C. and 9000 B.C. They used rocks to crush wild grain on other rocks. After farming began in about 8000 B.C., people made flour from such cultivated grains as barley, millet, rice, rye, and wheat.

By the 1000's B.C., millers ground grain between two large, flat millstones. Later, domestic animals or groups of slaves rotated the top stone to crush the grain. The ancient Greeks and Romans used water wheels to power flour mills. By the A.D. 1100's, windmills were powering flour mills in Europe.

Few further advances in milling occurred until 1780. That year, in England, a Scottish engineer named James Watt built the first steam-powered flour mill. During the late 1800's, metal rollers replaced millstones in many American and European mills. By the early 1900's, automation had made flour mills more productive than ever. The annual world wheat flour production now totals about 110 million metric tons.

See also **Bread; Gluten; Maize** (The dry-milling industry); **Pasta; Wheat** (Food for people).

Flour beetle is any of several small, reddish, flattened beetles that breed in flour, meal, and other grain products. They often spoil the food. Adult flour beetles are about 4 millimetres long. Flour beetles are found in all parts of the world, and all year long, in warm buildings.

Scientific classification. The flour beetle belongs to the family Tenebrionidae. Common species are *Tribolium confusum* and *T. castaneum.*

Flow chart. See **Computer** (Preparing a program; diagram: An operations flow chart).

Desert wild flowers thrive in hot, dry climates. A variety of flowering plants, such as cactuses, can survive for many months without rain.

Flower

Flower is a blossom, or an entire plant that is known for its blossoms. Most plants have flowers. Many flowers are brightly coloured and showy. Plants that have such flowers include buttercups, dandelions, orchids, roses, tulips, and violets. These flowers are also sweet smelling in order to attract animals (mainly insects), which *pollinate* (transfer pollen from the male parts of a flower to the female parts of a flower) them. Flowers may be flat and open, like those of water lilies, or narrow and tube-shaped, such as the flower of the tobacco plant. Some trees, such as horse chestnuts and magnolias, have beautiful flowers. But the trees themselves are not usually referred to as flowers. All the plants classified as either garden flowers or wild flowers are smaller than trees.

People often use flowers to express their deepest feelings. For more than 50,000 years, people have placed flowers on the graves of loved ones as a sign of remembrance and respect. Flowers are used at weddings to symbolize love, faithfulness, and long life. Certain flowers also have a religious meaning. Among Christians, for example, the white Easter lily stands for purity. Buddhists and Hindus regard the lotus, a type of water lily, as a sacred flower.

Originally, all flowers were wild flowers. Prehistoric people found wild flowers growing nearly everywhere, from the cold wastes of the Arctic to the steaming jungles of the tropics. In time, people learned to grow plants from seeds. By 3000 B.C., the Egyptians and other peoples of the Middle East had begun to cultivate a variety of garden flowers, including jasmines, poppies, and water lilies. Gardeners have since developed many other kinds, and cultivated flowers are now grown in every country. Thousands of species of flowers still grow in the wild throughout the world. But many of these species are becoming rare as more and more wilderness areas are levelled to make room for farms and cities.

Every flower has male or female parts– or both male and female parts. The male and female parts together produce the seeds. The seeds develop in a female part called an *ovary,* which is a hollow structure at the base of a flower. Before the seeds can develop, however, they must be fertilized by sex cells in the pollen produced by the male parts of a flower. In most kinds of flowering plants, the pollen is carried from the male parts of one flower to the female parts of another flower. The wind pollinates some kinds of flowers, especially those that have small, plain blossoms, such as docks, nettles, and some trees. Insects or birds pollinate most plants with showy or sweet-smelling flowers.

In the tropics, some species of bats pollinate flowers. The bats behave like large insects. Their long tongues

Interesting facts about flowers

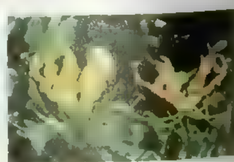
Yucca flowers of the Southwestern United States are pollinated by female yucca moths, which lay their eggs in the flowers' seed-producing organs. The eggs hatch into caterpillars, which feed on the seeds.

The night-blooming cereus is a climbing cactus with large, fragrant, white flowers that open only at night. The plant grows in Hawaii, U.S.A.; the West Indies; and other areas that have a tropical climate.

Red-hot pokers have long, slender stems topped by spikes of small, brilliantly coloured flowers. They belong to the lily family and may reach a height of about 1.5 metres. Most red-hot pokers grow wild in South Africa.

Stone plants of South Africa have leaves that look like the stones among which the plants grow. Each plant has two fleshy leaves. A white or yellow flower grows in a slit between the tops of the leaves.

The fly orchid of southern Ecuador has the shape and colouring of a female tachinid fly. This resemblance attracts male tachinid flies. The males pollinate fly orchids as they travel between the flowers.



Gloriosa lilies have long, graceful *stamens* (male reproductive parts) that grow outside the petals. The stems may measure up to about 1.8 metres tall. The flowers grow in Asia and Africa.

The rafflesia is the world's largest flower. It measures up to about 90 centimetres across. Rafflesias grow in Indonesia. They have no stems or leaves and are parasites on other plants.

Poinsettias have petallike leaves called *bracts, left,* that surround the plants' tiny flowers, *right.* Most poinsettias have red bracts. The plants are native to Mexico and Central America.

lap up nectar from the flowers and in doing so they dislodge pollen from the flower onto their body. They then carry the pollen to other flowers. In Australia, honey possums (small marsupials) pollinate large banksias.

Some flowers are *self-pollinating* (they pollinate themselves). In some other flowers, self-pollination occurs only when *cross-pollination* (the transfer of pollen from one flower to another) has failed.

Plants that have flowers are classified scientifically as *angiosperms.* The word *angiosperm* comes from two Greek words meaning *covered* and *seed.* All angiosperms bear their seeds in the protective covering. Before the seeds are fertilized, they are protected in the ovary. After the seeds are fertilized, the ovary grows into a structure called a *fruit.* The fruit encloses and protects the ripening seeds. The rest of the bloom slowly dies.

Scientists estimate that there are more than 350,000 *species* (kinds) of plants in the world. About 250,000 species are flowering plants, or angiosperms. All garden flowers and wild flowers belong to this large group, as do nearly all other familiar plants. One major exception is cone-bearing plants. Like angiosperms, cone-bearing plants reproduce by means of seeds. The seeds are produced by the cones. The cones develop from structures that resemble the plain flowers of some angiosperms. But these structures lack an ovary and therefore are not considered to be flowers in the strict sense of the word.

This article describes the uses of flowers, the various kinds of garden flowers and wild flowers, and the parts of a flower. It then discusses the role of flowers in reproduction, flower hobbies, and how flowers are named and classified. For detailed information about flowering plants in general, see the *World Book* article **Plant.** *World Book* also has hundreds of articles on individual flowers and flowering shrubs. For a list of these articles, see the *Related articles* at the end of this article.

Tulip farms in the Netherlands, *above*, produce millions of tulip bulbs annually. Other kinds of flowers that are grown commercially from bulbs include varieties of daffodils, hyacinths, and narcissuses.

The blossoms of most flowering plants have little food value compared with other plant parts, such as the roots, leaves and fruit. Most blossoms also lack useful chemicals or other materials that can be used in manufacturing. People use flowers mainly as decoration and in landscaping. The production and marketing of flowers for these purposes is a major industry in many countries.

As decoration. Flowers are widely used as table decorations in homes and restaurants. In churches and other places of worship, flowers often decorate the altars. Many women wear flowers in their hair or pinned to their dress. Hawaiians often wear flower necklaces called *leis*. Flowers add beauty and colour to many public festivals. Patterns based upon flowers are widely used by fabric designers for clothing and upholstery, and flowers are a major source of inspiration to artists and craftsmen throughout the world.

The flowers used as decoration may be either cut flowers or flowering house plants. Cut flowers are garden flowers that were harvested while in bloom. Cut flowers stay fresh for several days if their stems are kept in water. Popular cut flowers include daisies, gladioli, irises, and roses. Flowering house plants have showy blossoms and can be grown indoors in containers. Such plants include African violets, azaleas, and wax begonias. Unlike cut flowers, flowering house plants may last almost indefinitely.

Colourful leis, which consist of flowers strung together, are worn as necklaces in Hawaii and other Pacific islands. Favourite flowers for leis include carnations, jasmines, and orchids.

Many home gardeners grow their own cut flowers. Cut flowers are grown commercially in greenhouses and on flower farms. House plants also are grown commercially in greenhouses, and in nurseries. Commercial producers sell their flowers to retail florists, who resell them to the public. Many florists—especially those who supply flowers for such occasions as weddings and funerals—are trained in the art of flower arranging. The section *Flower hobbies* discusses flower arranging.

In landscaping. Flowers add greatly to the beauty of gardens, parks, and other landscaped areas. The flowers may be planted in beds or borders and arranged according to size, shape, and colour. Spring, summer, and autumn varieties may be planted to provide a continuous display of blooms. Some of the most popular plants used in landscaping are flowering shrubs, such as forsythias, hydrangeas, lilacs, and spiraeas. Flowering shrubs are especially useful in large landscaped areas because they flower year after year and require little care.

Many public gardens and parks are noted for their beautiful displays of flowers. The Moorish gardens of southern Spain, like those near the Alhambra Palace in Granada, are beautifully laid out, with myrtle and citrus bushes, and aromatic herbs. The water gardens of the Villa d'Este, in Tivoli, Italy, feature peonies and are typical of many fine Italian Renaissance gardens. The Mughal Gardens of India are bright, with formal flower beds, set among lakeside lawns. Singapore Botanic Gardens is famous for rare palm trees. The Royal Botanic Garden at Peradeniya, Sri Lanka, has a magnificent assortment of tropical flowers, especially orchids. In the United States, Golden Gate Park, in San Francisco, California, has one of the world's largest collections of rhododendrons, and the Missouri Botanical Garden, in St. Louis, is well known for its water lilies.

Other uses. In most cases, the flower buds or blossoms of flowering plants do not serve as food for people. There are some exceptions, however. The flower buds of broccoli, cauliflower, and globe artichoke plants are widely used as vegetables. Broccoli and cauliflower buds grow in thick clusters called *heads.* The heads are eaten with the stems. Artichoke buds grow singly, and only the bud is eaten. Certain seasonings also come from flower buds or flower parts. For example, cloves are the dried flower buds of the clove tree. Saffron comes from female flower parts of autumn crocuses. The petals of some flowers, such as roses and marigolds, have a sweet or spicy taste. They are sometimes used to flavour soups and salads, especially in Europe and Asia. Some people use dandelion and elderberry blossoms to make wine. In China, lightly fried vegetable marrow flowers are a great delicacy.

Honey is made from *nectar,* a sugary liquid produced by flowers. Bees gather nectar from flowers. They eat some of it and store the rest in their hives. The nectar in the hives gradually turns into honey. Some flowers are better suited to honey production than others because they produce more and tastier nectar. Such flowers include alfalfa, buckwheat, clover, orange, and sage.

The petals of certain flowers contain sweet-smelling oils. Such flowers include jasmines, mimosas, and roses. The oils obtained from the petals of these flowers supply the fragrances for many high-quality perfumes. However, most perfumes are made synthetically from chemical substances.

Building a flower-covered float, *above,* requires thousands of blossoms. Elaborate floats decorated with roses, carnations, and other flowers are spectacular features of many parades.

Perfumes made from petals are the most delicate and expensive scents. Sweet-smelling oils from the petals of such flowers as roses are extracted after the petals are aired, *above.*

Botanical gardens display collections of flowering plants, shrubs, and trees from many parts of the world. Canada's beautiful Butchardt Gardens, *above,* near Victoria, British Columbia, include an English rose garden and Italian and Japanese gardens.

Garden flowers

Garden flowers are simply cultivated wild flowers. Some kinds of garden flowers are exactly like the wild species. Other kinds have been bred scientifically so that their blooms are more attractive than those of the wild variety. Garden flowers are grown on farms and in nurseries and greenhouses as well as in home gardens. Some kinds also make excellent house plants.

Garden flowers can be divided into three main groups based on how long they live: (1) annuals, (2) biennials, and (3) perennials. Annuals are plants that sprout from seed, grow to full size, bloom, produce seeds, and die—all within one year or less. Biennials are plants that live for two years. They do not produce blooms and seeds until their second year of growth, after which they die. Annuals and biennials live such a short time that each generation must produce many seeds for the species to survive. Each plant uses up all its food energy in the production of blooms and seeds and so dies soon afterward. All annuals and biennials are *herbs*—that is, they have soft stems.

Perennials are plants that live for at least three years. They may or may not bloom during their first year of growth. But after perennials have begun to bloom, they may do so every year almost indefinitely, depending on their species. Because perennials live longer than annuals and biennials, they do not have to produce as many seeds for the species to survive. Instead of using up all their food energy in seed production, the plants store some of it in their roots. Perennials thus go on living after their blossoms have faded and died.

Some perennials are herbs. The stems of these herbaceous perennials wither and die at the end of each summer. But their roots survive through the winter and grow new stems in spring. All other perennials, including flowering shrubs, have woody stems. Woody perennials do not wither at the end of summer. However, most of them shed their leaves in autumn and rest in winter. Some kinds of herbaceous perennials grow from bulbs. Bulbs and flowering shrubs are not grown in the same way as other perennials, and so they are usually discussed separately.

The great majority of garden flowers are annuals or perennials. Only a few are biennials. However, the classification of flowers as annuals, biennials, or perennials is not always precise. For example, most perennials that are native to warm climates cannot survive cold winters. These flowers therefore cannot be grown as perennials in such places as Canada, Finland, and the northern parts of the Soviet Union. But some warm-weather perennials, such as gloxinias and wax begonias, bloom during their first year of growth. They can thus be grown as annuals in northern climates.

Garden annuals

Most annuals flower about 8 to 10 weeks after the seeds are planted. In warm climates, annuals can be planted outdoors at any time of the year. In areas with cold winters, they are usually planted in spring. Certain species can survive a light frost and so may be started outdoors from seed as soon as the ground has thawed completely. These *hardy annuals* include cornflowers, marigolds, pansies, sunflowers, and sweet alyssum. However, some hardy annuals, such as pansies and petunias, grow slowly. Gardeners give these flowers a head start by planting them as seedlings. Some gardeners grow their own seedlings. Others buy them from garden centres. In either case, the seeds are planted indoors in late winter or early spring. The seedlings are then ready to be transplanted outdoors as soon as the ground has completely thawed.

Some annuals, such as garden balsams and French marigolds, cannot survive even a light frost. These *half-hardy annuals* should not be planted outdoors until all danger of frost has passed. In northern regions, frosts may occur for a month or more after the ground has thawed. Gardeners in these regions almost always give half-hardy annuals a head start by sowing the seeds indoors before the growing season begins. They then plant the seedlings outdoors in spring.

Sweet pea
Lathyrus odoratus

Morning-glory
Ipomoea purpurea

Petunia
Petunia hybrida

Nasturtium
Tropaeolum majus

Snapdragon
Antirrhinum majus

Zinnia
Zinnia elegans

Cornflower
Centaurea cyanus

French marigold
Tagetes patula

Sunflower
Helianthus annuus

Larkspur
Consolida ambigua

Garden balsam
Impatiens balsamina

Pansy
Viola tricolor

Cosmos
Cosmos bipinnatus

Garden biennials

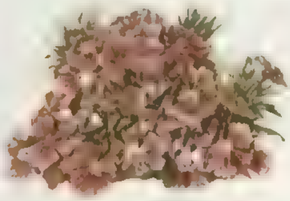
Gardeners who wish to start biennials outdoors usually plant the seeds in midsummer. The plants grow a stem and a few leaves by autumn. The leaves and stem then die, but the roots survive through the winter. The plants grow a new stem, bloom, produce seeds, and die during their second growing season. Instead of starting biennials outdoors, many gardeners buy them as seedlings in spring and raise them like annuals.

Hollyhock
Althaea rosea

Canterbury bells
Campanula medium

Foxglove
Digitalis purpurea

Iceland poppy
Papaver nudicaule



Sweet William
Dianthus barbatus

Garden perennials

Popular garden perennials include asters, bleeding hearts, chrysanthemums, columbines, day lilies, delphiniums, irises, lupins, peonies, phloxes, poppies, primroses, and violets. Most of these flowers need an annual cold or cool season for the growth of new buds. They therefore do not grow well in tropical climates. On the other hand, warm-weather perennials may be grown indoors in northern climates, and many of them are favourite house plants. Some of these perennials are pictured in the next section of the article under the heading *Flowers of the tropics and subtropics.* They include such flowers as African violets, gloxinias, ivy geraniums, and wax begonias.

Some perennials, such as columbines and delphiniums, bloom for only three or four years. Most gardeners start these plants from seeds and replace them when necessary. In most cases, longer-living perennials are started from *cuttings*—that is, pieces cut from the stems or roots of adult plants. When planted in water or soil, a cutting develops into a plant identical to the parent. Cuttings, like seedlings, should be started indoors. Some gardeners start cuttings taken from their own plants. Others buy cuttings that have already rooted.

Perennials should be set into the garden in spring or early autumn. In general, spring is the best time to plant perennials outdoors in northern regions. Early autumn is usually the best time in warmer climates.

Most perennials spread by sending out shoots from their roots. The shoots develop into new stems. Most species produce new shoots soon after they have flowered each year. Over several years, the offshoots from only one plant may cover a wide area. In most cases, however, the plants flower better if they are dug up, divided, and replanted every few years.

Lily of the valley
Convallaria majalis

Michaelmas daisy
Aster novi-belgii

Bearded iris
Iris germanica

Polyanthus
Primula polyantha

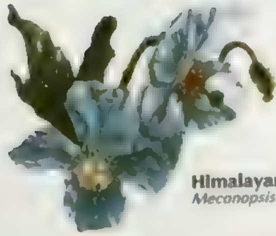
Peony
Paeonia officinalis

Lupin
Lupinus polyphyllus

Violet
Viola odorata

Chrysanthemum
Chrysanthemum morifolium

Christmas rose
Helleborus niger



Himalayan blue poppy
Meconopsis betonicifolia

Phlox
Phlox paniculata

Oriental poppy
Papaver bracteatum

Delphinium
Delphinium grandiflorum

Day lily
Hemerocallis fulva

Canna
Canna generalis

Bleeding heart
Dicentra spectabilis

Balloon flower
Platycodon grandiflorus

Garden perennials (Bulbs)

A bulb is an underground stem with a large bud, wrapped in starchy tissue. The bud develops into a new plant after the weather becomes favourable. The starchy tissue provides the developing plant with food.

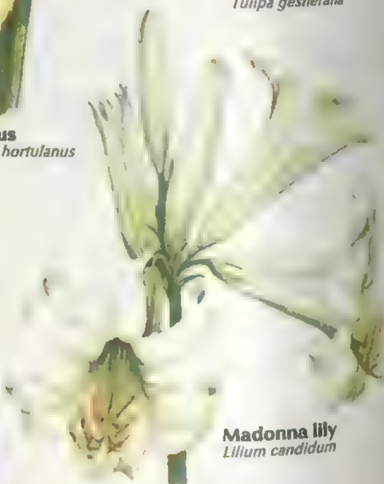
Flowers that grow from bulbs or bulblike structures include crocuses, daffodils, fritillaries, gladioli, hyacinths, Madonna lilies, tuberous begonias, and tulips. Plants such as crocuses and tulips grow better in cool climates than in warm ones. The bulbs of daffodils, hyacinths, and some other flowers can be left in the ground through the winter. Certain other flowers, such as gladioli, cannot survive in extremely cold weather. In northern regions, the structures from which these plants grow should be dug up in autumn, stored indoors, and then replanted outdoors in spring. Many kinds of bulbs grow best in well-drained soil, in a sunny, sheltered position.

Gladiolus
Gladiolus hortulanus

Tulip
Tulipa gesnerana

Crocus
Crocus susianus

Begonia
Begonia tuberhybrida



Madonna lily
Lilium candidum

Dahlia
Dahlia pinnata

Crown imperial
Fritillaria imperialis

Daffodil
Narcissus pseudo-narcissus

Hyacinth
Hyacinthus orientalis

Garden perennials (Flowering shrubs)

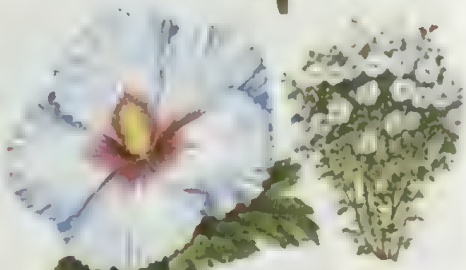
Shrubs, like trees, have woody stems. But shrubs do not grow as tall as trees, and most of them have two or more thin stems rather than a single thick one. As a rule, flowering shrubs grow best in areas with fairly long summers and cool winters. Most species cannot stand very cold weather. Popular kinds of flowering shrubs include azaleas, buddleia, flowering quince, forsythia, honeysuckle, hydrangeas, lilacs, roses, hibiscuses, and spiraeas.

Most beginning gardeners buy shrubs as young plants that are ready to set into the garden. However, gardeners can easily produce their own plants from mature shrubbery. Like herbaceous perennials, many shrubs spread by sending out shoots from their roots. Such shoots will develop into new plants if they are dug up with part of the root and replanted. Shrubs that do not send out shoots can be reproduced from cuttings.

Hybrid tea rose
Rosa dilecta

Azalea
Rhododendron calendulaceum

Honeysuckle
Lonicera tatarica



Hibiscus
Hibiscus syriacus

Spiraea
Spiraea prunifolia

Forsythia
Forsythia intermedia

Hydrangea
Hydrangea macrophylla

Lilac
Syringa vulgaris

Wild flowers

A carpet of wild flowers brightens a mountain meadow. Wild flowers grow almost everywhere —in woods, fields, grasslands, deserts, jungles, and swamps; on mountains; and along rivers and seacoasts. Each environment promotes the growth of different kinds of flowers.

Each species of flowering plant grows best in a particular type of environment. The species may be unable to grow at all in a much hotter, cooler, wetter, or drier location. Gardeners can control a plant's environment to some extent. They can grow certain flowers in otherwise unfavourable locations. For example, flowers that need considerable moisture can be grown in dry climates if the gardener supplies the flowers with the necessary water. When flowers grow in the wild, however, they do not receive such special treatment. Each species can survive only in the type of environment to which it is naturally suited.

There are about 250,000 kinds of flowering plants in the world. About 165,000 species of flowers are native to the tropics. The remaining 85,000 species are native to Europe, North America, and other nontropical regions.

There are seven major wild flower habitats. These habitats are (1) the Arctic tundra, (2) woodlands and forests, (3) grasslands, (4) scrub, (5) alpine tundras, (6) deserts, and (7) tropical and subtropical regions. In addition, a major wild flower habitat may include various special environments, such as wetlands and shorelines. These special environments have their own types of wild flowers. For example, some varieties of woodland flowers grow mainly in woodland swamps. Water flowers may be found in any environment that has lakes or rivers.

Plants that grow in the same habitats often show similarities of form. For example, many desert plants have long roots to reach water supplies deep underground, and the fleshy stems of cacti are adapted to store water. Alpine and tundra plants often grow in cushionlike clumps or rosettes to protect themselves from the cold.

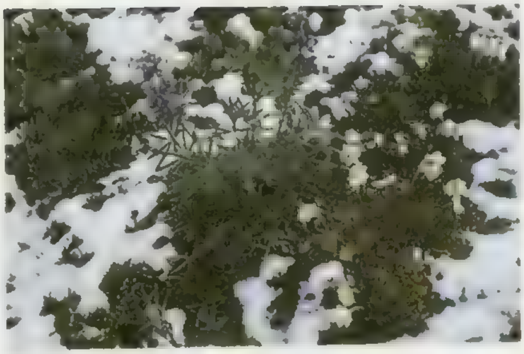
Many wild flowers have spread from their native environment to similar habitats in other parts of the world. Sometimes this spread has been a natural process, the seeds being carried by the wind or by animals. In other cases, flowers have been introduced by people to parts of the world where they did not grow naturally before. Some plants are specially adapted for rapid spreading. They make hundreds of seeds, which are dispersed long distances. Many such plants are called weeds, and they may appear very rapidly in places where they are not welcome—such as in gardens.

The Bermuda buttercup is a flower that grows naturally in South Africa, but which has spread to many other parts of the world, including Europe and South Australia. Widespread weeds of pasture and waste ground include many types of thistle, such as musk thistle and spear thistle. Other common weeds are bindweeds, dandelion, mulleins, oxeye daisy, plantains, and yarrow. See **Weed**.

The drawings in this section illustrate typical flowers of each major wild flower habitat.

Flowers of the Arctic tundra

The Arctic tundra extends across the northernmost parts of Europe, Asia, and North America. It is a cold, dry, treeless habitat. Most of the region has an annual frost-free period of less than two months. The ground remains frozen all year except at the surface. The surface thaws in spring and remains soggy throughout most of the summer. Seeds tend to rot in such cool, marshy ground, and so the tundra has few annuals. However, a variety of herbaceous perennials thrive in the tundra. These hardy plants include cinquefoils, fireweeds, louseworts, poppies, and saxifrages. They come to life suddenly in spring and brighten the Arctic summer with their colourful blossoms.

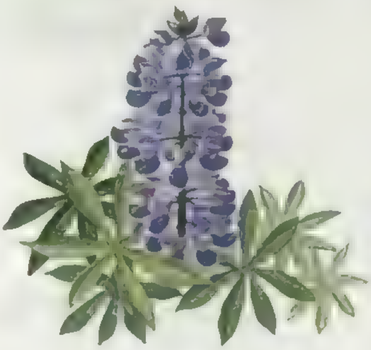


Arctic rhododendron
Rhododendron lapponicum

Cassiope
Cassiope tetragona

River beauty
Epilobium latifolium

Mountain avens
Dryas octopetala



Arctic lupin
Lupinus arcticus

Shrubby cinquefoil
Potentilla fruticosa

Purple mountain saxifrage
Saxifraga oppositifolia

Arctic poppy
Papaver radicatum

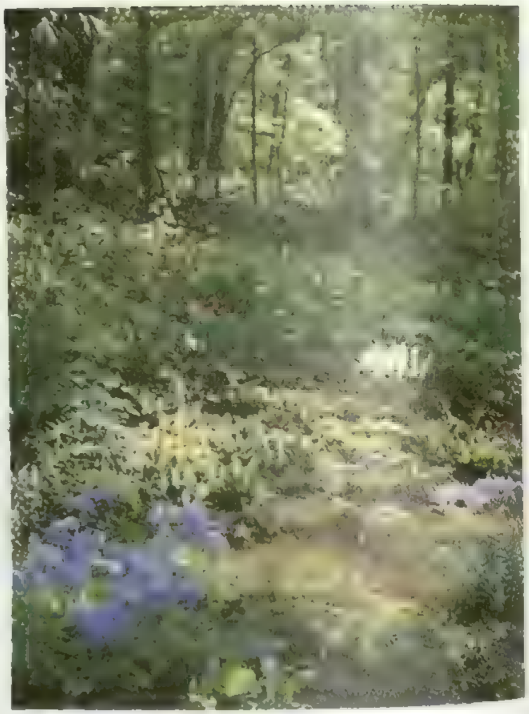
Woolly lousewort
Pedicularis lanata

Flowers of woodlands and forests

Woodlands and forests grow only in regions that have much moisture and a yearly frost-free period of over two months. Seedlings have difficulty competing with established plants in wooded areas, so such areas have few annuals. Nearly all the flowers are perennials.

There are two main types of forests: (1) needleleaf (or coniferous), and (2) broadleaf. *Needleleaf forests* stretch south from the Arctic tundra across northern Europe, northern Asia, and Canada. Needleleaf forests have many of the same kinds of plants as the tundra, such as bog orchids, hawkweeds, wintergreens, and meadowsweet. Twinflower and bilberry are also common.

The largest *broadleaf forests* outside the tropics are in western and central Europe, eastern Asia, and the eastern half of the United States. The growth of flowers in these forests is regulated largely by the amount of shade or sunlight. Many woodland plants flower early in the spring, before the trees develop their leaves and the woods become heavily shaded. Typical early-flowering woodland plants of Europe and northern Asia are various species of violets and wood anemones, lesser celandine, and common primrose. In the woods of eastern North America common species of spring and early summer include trillium, dogtooth violet, spiderwort, and touch-me-not (balsam). Summer-flowering woodland species include bellflower, forget-me-not, and willow-herb.



Needleleaf forest

Twinflower
Linnaea borealis

Indian pipe
Monotropa uniflora

Bilberry
Vaccinium myrtillus

Bunchberry
Cornus canadensis

Rocky Mountain columbine
Aquilegia caerulea

Labrador tea
Ledum groenlandicum

Broadleaf forest

Mezereon
Daphne mezereon

Dog violet
Viola riviniana

Wood anemone
Anemone nemorosa

Ramsons
Allium ursinum

Yellow anemone
Anemone ranunculoides

Lesser celandine
Ranunculus ficaria

Red helleborine
Cephlanthera rubra

Round-lobed hepatica
Hepatica americana

Marsh marigold
Caltha palustris

Solomon's seal
Polygonatum multiflorum

Gary goldenrod
Solidago nemoralis

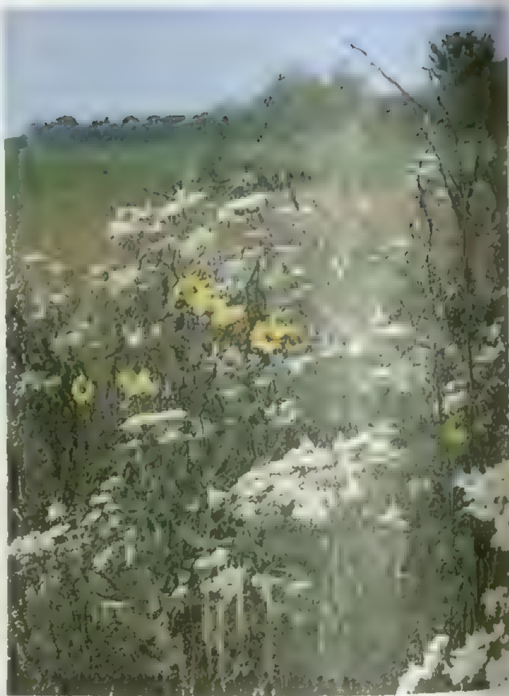
Large-flowered trillium
Trillium grandiflorum

Flowers of grasslands

Steppe grassland is found in parts of southeast Europe, Russia, Ukraine, East Africa, South America (mainly in Argentina), the central United States, and south-central Canada. In Hungary, steppe grassland is known as *puszta.* Like the *steppes* of Russia, the puszta is dominated by feather-grasses. The grasslands of South America are known as *pampas;* those of North America are known as *prairies.* These grasslands are found in regions that have a temperate climate, with cool or cold winters, and hot, rather dry summers.

Steppe grasslands develop on very fertile soils. These areas are noted for their tall grasses and spring, summer, and autumn flowers. The grasses grow so close together that few seeds can penetrate, and annuals therefore find it difficult to survive. Most grassland flowers are perennials. In drier areas, the long grasses give way to shorter, drought-resistant species. The Russian steppes contain flowers such as the Siberian tansy, yellow adonis, and narrow-leaved peony. A beautiful flower of South American grasslands is the slipperplant. Typical prairie flowers are blazing stars, pasqueflowers, coneflowers, rattlesnake masters, sunflowers, tickseeds, and wild indigo.

In tropical areas, a different kind of grassland is found, the *savanna.* Savanna grassland is very dry, with scattered tall trees. It is found in East Africa, Australia, and South America (in Brazil and Venezuela).



Pheasant's eye
Adonis aestivalis

Pink mulla-mulla
Ptilotus exaltatus

Pampas grass
Cortaderia selloana

Wild onion
Allium rotundum

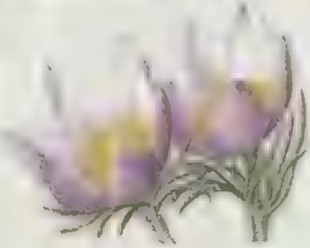
Peony
Paeonia mascula

Prairie rose
Rosa arkansana

Prairie buttercup
Ranunculus rhomboideus

Gaillardia
Gaillardia pulchella

Rattlesnake master
Eryngium yuccifolium



Pasqueflower
Anemone nuttalliana

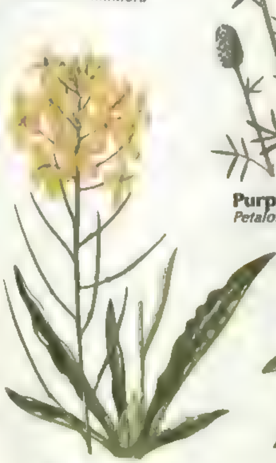
Prairie coneflower
Ratibida columnifera

Tickseed
Coreopsis tinctoria

Saline shooting star
Dodecatheon pauciflorum

Purple prairie clover
Petalostemon purpureum

White wild indigo
Baptisia leucantha



Western wallflower
Erysimum asperum

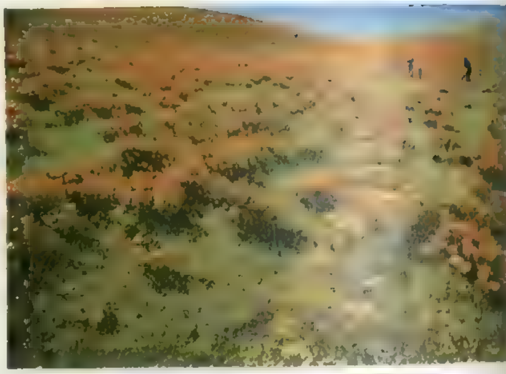
Low townsendia
Townsendia sericea

Plains prickly pear cactus
Opuntia polyacantha

Flowers of scrub

Scrub vegetation consists of thick growths of shrubs and scrubby trees. It is typical of areas with a Mediterranean climate—hot, dry summers and mild, wet winters. These areas are found around the Mediterranean Sea, and in Australia, South Africa, and California, U.S.A.

In the Mediterranean region, scrub vegetation is known as *maquis* or *garrique;* in South Africa, *fynbos;* and in California, *chaparral.* In Europe and California, evergreen oaks with leathery leaves dominate the vegetation. Many of the wild flowers are heavily scented with aromatic oils. Examples are rock-roses and such herbs as lavender and sage. In coastal parts of Western Australia, there are large areas of low scrub called *heath,* made up of shrubs such as banksias and hakeas.



Grevillea punicea

Bladder senna
Colutea arborescens

French lavender
Lavendula stoechas

Ochna macrocalyx

California poppy
Eschscholzia californica

Fire poppy
Papaver californicum

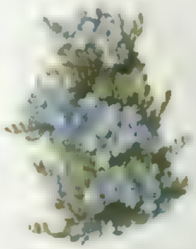
Goldfields
Lasthenia chrysostoma

Five-spot
Nemophila maculata

Flowers of alpine tundras

Alpine tundras lie at high elevations in mountains throughout the world. Like the Arctic, these areas are too cold and dry for trees to grow. However, grasses, low shrubs, and a variety of wild flowers thrive. The chief alpine tundras are in the European Alps, the Himalaya of Asia, and the Rocky Mountains of North America. Most alpine flowers grow in mountain meadows, but some species are especially suited to rocky places. As in the Arctic, the yearly frost-free period is usually less than two months, and so nearly all the flowers are perennials. Most are small and grow slowly, and some do not even start to bloom until they are 10 years old or older. Many alpine and Arctic flowers are closely related, and some are identical.

Club-moss ivesia
Ivesia lycopodioides



Alpine forget-me-not
Eritrichium elongatum

Saxifrage
Saxifraga tolmiei

Bitterroot
Lewisia pygmaea

Moss campion
Silene acaulis

Arctic gentian
Gentiana algida

Alpine avens
Geum rossii

Alpine phacelia
Phacelia sericea

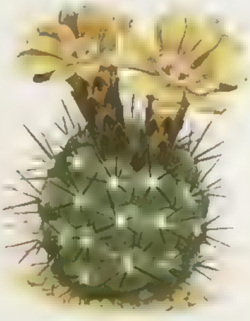
Sticky polemonium
Polemonium viscosum

Flowers of the desert

Deserts are extremely dry regions with a generally warm climate. Most deserts receive less than 25 centimetres of rainfall a year. In some cases, all the rain falls in one or two tremendous cloudbursts. Desert flowers must therefore be able to survive for many months without rain.

Some desert flowers are shrubs. These plants have vast networks of roots that absorb every available drop of moisture in the soil. Other desert flowers are herbaceous perennials with thick, spongy stems. The stems store water, which the plants use during the long dry spells. Cactuses are the best-known examples of this type of plant. Still other flowers are annuals. Annuals thrive in deserts because they have relatively few perennials to compete with. In addition, the seeds of annuals can survive even the longest dry periods. The seeds lie buried until the rains return. They then sprout, and the plants complete their life cycle within a few weeks.

In the deserts of Australia, the dominant plants are tussock grasses, such as porcupine grass or spinifex, and succulent herbs, such as parakeelya. After the rains, the deserts come alive with beautiful flowers, such as the purple mulla-mullas. In the deserts of North and Central America, cactuses are prominent. Cactuses are protected from grazing animals by their sharp spines. Many cactuses have beautiful flowers. In Africa, the most abundant desert plants are the euphorbias, which have a poisonous milky sap.



Weingartia neumanniana

Living stones
Lithops lesliei

Crown of thorns
Euphorbia milii

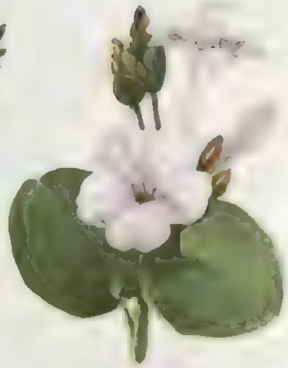
Ice plant
Mesembryanthemum crystallinum

Aloe jacunda

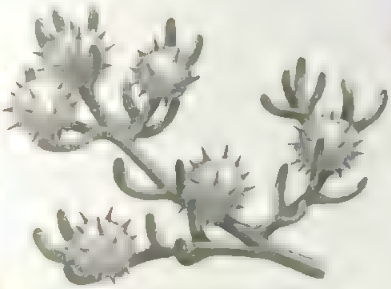
Desert bluebell
Phacelia campanularia

Ghost flower
Mohavea confertiflora

Arizona poppy
Kallstroemia grandiflora



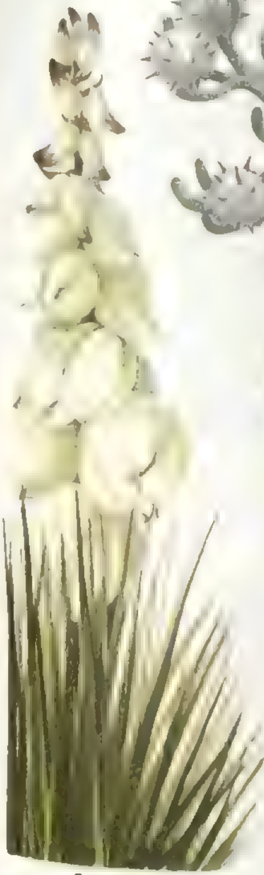
Giant four-o'clock
Mirabilis froebelii



Cannon ball
Bassia paradoxa

Desert chicory
Rafinesquia neo-mexicana

Beaver-tail cactus
Opuntia basilaris



Soapweed
Yucca glauca

Birdcage evening primrose
Oenothera deltoides

Desert mallow
Sphaeralcea ambigua

Desert lily
Hesperocallis undulata

Flowers of the tropics and subtropics

Thousands of species of wild flowers grow in the humid and warm to hot climate of the tropics and subtropics. The tropical rainforests of Central and South America have the greatest variety of tropical flowers, including hundreds of rare and beautiful orchids. About 2,000 species of flowering plants are native to Hawaii, U.S.A. However, many have become extinct or extremely rare as a result of land development and overpicking. Southern regions of China and South Africa have a rich assortment of subtropical flowers. Wild flowers from the tropics and subtropics are grown in cooler climates as indoor and greenhouse plants. Many have shiny, decorative foliage, and large, attractive flowers.

African violet
Saintpaulia ionantha

Bird-of-paradise
Strelitzia reginae

Ivy geranium
Pelargonium peltatum

Clamshell orchid
Epidendrum cochleatum

East Indian lotus
Nelumbo nucifera

Wax begonia
Begonia semperflorens

Gloxinia
Sinningia speciosa

Cape jasmine gardenia
Gardenia jasminoides

Torch ginger
Nicolaia elatior

The typical flower develops at the tip of a flower stalk. The tip is somewhat enlarged, forming a cup-shaped structure called a *receptacle.* A bud grows from the receptacle and develops into a flower.

Most flowers have four main parts: (1) the calyx, (2) the corolla, (3) the stamens, and (4) the pistils. The calyx is the outermost part of a flower. It consists of a set of leaflike or petallike structures called *sepals.* The corolla consists of a flower's petals. The stamens and pistils make up the reproductive parts of flowers. The stamens are the male parts, and the pistils are the female parts. Every flower has either stamens or pistils—or both stamens and pistils. Flowers that have all four main parts are called *complete flowers.* Flowers that lack one or more of the parts are called *incomplete flowers.* In addition to the main parts, many flowers have glands that produce nectar. These glands, which are called *nectaries,* lie near the base of the flower.

In most flowers, each main part consists of three, four, or five elements or of multiples of three, four, or five elements. In a trillium, for example, three sepals form the calyx, and three petals form the corolla. The flower has six stamens, and the pistil is composed of three equal parts. The elements may be separate from one another, like the petals of a poppy or a rose. Or the elements may be *fused* (joined together). In flowers with fused petals, the corolla is shaped like a tube, bell, trumpet, pouch, or saucer. Flowers that have such corollas include morning-glories, daffodils, and petunias. In such species as evening primroses and verbenas, the petals are fused at the base and free at the tip. The corolla of this type of flower thus has a tubelike or bell-like base and a fringed edge.

In buttercups, morning-glories, and most other flowers, all the main parts are arranged around the centre of the flower in a circular fashion. If the flower is divided in half in any direction, the halves will be alike. Such flowers are *radially symmetrical.* Orchids, snapdragons, sweet peas, and certain other flowers can be divided into identical halves only if the blossoms are cut through lengthwise. Such kinds of flowers are *bilaterally symmetrical.*

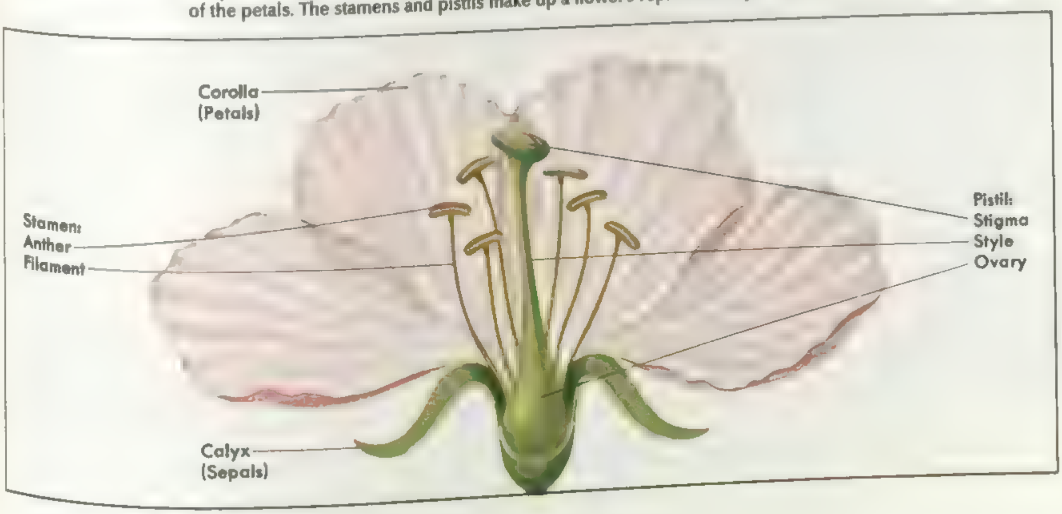
The calyx. The sepals, which make up the calyx, are the first parts to form in the majority of flowers. They protect the developing inner parts of the flower. In most cases, the sepals remain attached to the flower after it opens.

In many flowers, such as buttercups and magnolias, the sepals are greenish, leaflike structures that are on the underpart of the flower. Other flowers have sepals that look like petals. In many members of the iris, lily, and orchid families, the sepals and the petals look so much alike that they cannot be told apart. Botanists call these petallike structures *tepals.* Certain kinds of flowers have colourful sepals in place of petals. These flowers include anemones, hepaticas, larkspurs, and marsh marigolds.

The corolla, which consists of a flower's petals, is the showy, brightly coloured part of most flowers. The colours of the petals—and of coloured sepals—attract insects or birds that help spread a flower's pollen. The colours come from certain chemicals in a plant's tissues. These chemicals are present in all parts of the plant, not only the petals or sepals. But they are masked in the other parts by large amounts of green or brown pigments. Many flowers also have spots, stripes, or other markings on their petals that attract insects or birds. In most cases, the odours of flowers come from oily substances in the petals. Strong odours, like bright colours, attract animals.

The stamens are the male, pollen-producing parts of a flower. They are not particularly noticeable in most flowers. In some cases, however, the stamens make up a flower's most attractive part. Male acacia flowers, for example, consist mainly of a large feathery tuft of colourful stamens.

Parts of a flower A typical flower has four main parts. They are (1) the calyx, (2) the corolla, (3) the stamens, and (4) the pistils. The calyx forms the outermost part and consists of leaflike *sepals.* The corolla consists of the petals. The stamens and pistils make up a flower's reproductive parts.



Variations in flower structure

Flowers differ in the shape, number, and colour of their main parts. In addition, some species lack one or more of these parts. The examples below illustrate four variations in flower form.

A composite flower is many small flowers. The daisy has tiny *disc flowers* in the centre and individual *ray flowers* that look like petals.

A leaflike spathe surrounds the tiny flowers of the skunk cabbage. The flowers grow in a cluster on a stalk. Some spathes have bright colours.

Large white bracts encircle the flowers of the dogwood. Many people mistakenly think that the attractive bracts are part of the flower.

Long red stamens make up the showiest part of bottle-brush flowers. The stamens form a spike that resembles a brush used to wash bottles.

In most flowers, each stamen has two parts—a *filament* and an *anther*. The filament is a threadlike or ribbonlike stalk with an enlarged tip. The enlarged tip forms the anther. The anther consists of four tiny baglike structures that produce pollen. After the pollen is ripe, these structures split open, which releases the pollen grains.

The stamens are separate from one another in many flowers. But in such species as hollyhocks and sweet peas, some or all of the filaments are fused and form a tube around the pistil. In some flowers, the stamens are fused with one or more other flower parts. For example, the stamens of gentians are fused to the petals, and the stamens of most orchids are fused to the pistils.

The pistils are the female, seed-bearing parts of a flower. Some flowers, including all members of the pea family, have only one pistil. But most flowers have two or more. In many species, the pistils are fused into one *compound pistil*. A compound pistil is often referred to simply as a pistil. The individual pistils that make up a compound pistil are called *carpels*.

In most flowers, each pistil or carpel has three parts—a *stigma*, a *style*, and an *ovary*. The stigma is a sticky area at the top. The style consists of a slender tube that leads from the stigma to the ovary. The ovary is a hollow structure at the base. It contains one or more structures called *ovules*.

Variations in flower structure. Many kinds of flowers grow in clusters called *inflorescences*. In some species, such as snapdragons and spiraeas, the individual flowers in each cluster are easy to identify as flowers. In numerous other species, however, the inflorescence looks like one flower and the individual flowers that make up the inflorescence look like petals. These species include the many members of the *composite family*, such as asters, chrysanthemums, daisies, dandelions, and sunflowers.

In the members of the composite family, the flowers grow from a *head* at the tip of the flower stalk. Each head has several or many flowers, depending on the species. A dandelion head, for example, may have 100 or more tiny yellow flowers. Each flower, or *floret*, looks like a petal but consists of a calyx, a corolla, stamens, and a pistil. One petal makes up the corolla. The dandelion florets grow so close together that only their corollas can be seen.

The flowers of some plants grow in plain, tassellike inflorescences called *catkins*. A catkin is composed of *naked flowers*—that is, flowers that lack both petals and sepals. Plants that have catkins include alders, poplars, and willows.

Many plants that have inflorescences also have leaflike structures called *bracts* just beneath each flower cluster. In most cases, bracts are small, green, and barely noticeable. But in a few species, they are so large and showy that most people mistake them for part of the flower. The showy "petals" of bougainvilleas, dogwoods, and poinsettias are bracts. The flowers themselves are small, plain-looking inflorescences at the centre of the bracts.

In most species of flowering plants, each plant bears flowers that have both stamens and pistils. Such flowers are called *perfect flowers*. In some species, however, each plant bears flowers that have either pistils or stamens, not both. Such flowers are called *imperfect flowers*. If a flower has pistils but no stamens, it is called a *pistillate flower*. If it has stamens but no pistils, it is called a *staminate flower*.

In some species, the staminate and pistillate flowers are on the same plant. Such species are known as *monoecious* species. They include begonias, oaks, and gourds. In *dioecious* species, the male and female flowers are on different plants. Dioecious species include holly, poplars, and willows.

Flowering plants reproduce sexually. The sexual parts of their blossoms produce male and female sex cells. The male cells, called *sperm*, are in the pollen produced by the stamens. The female cells, called *eggs*, are in the ovules produced by the pistils. The sperm and egg cells unite in the ovary at the base of a pistil and develop into seeds.

Reproduction in flowers involves two main steps: (1) pollination and (2) fertilization. Pollination is the transfer of pollen from a stamen to a pistil. Fertilization is the union of a sperm with an egg cell. Fertilization occurs in much the same way in all flowering plants. However, there are two methods of pollination: (1) cross-pollination and (2) self-pollination. Cross-pollination involves the transfer of pollen from a stamen on one plant to a pistil on another plant. In self-pollination, pollen is transferred from a stamen of one flower to a pistil of the same flower or to the pistil of another flower on the same plant.

Cross-pollination is the method of pollination in most flowering plants. The method requires an *agent* to carry the pollen from flower to flower. Insects are the most common agents of cross-pollination.

Many insects depend on flowers for food. Bees live on nectar and pollen. They also use nectar to make honey, which they feed on in winter. Butterflies and moths also live on nectar, and certain beetles and flies feed on both nectar and pollen. As an insect travels from flower to flower in search of food, pollen grains stick to its body. Some or all of these grains may brush off onto the stigmas of some flowers that the insect visits. One or more of these flowers may thus become cross-pollinated.

When searching for food, an insect could easily fail to visit a particular kind of flower unless the insect was attracted to it. Most flowers that depend on insects for pollination are brightly coloured or heavily scented. Each kind of pollinating insect is attracted by certain colours or odours and so visits certain flowers rather than others. However, more than one kind of insect pollinates most insect-pollinated flowers. For example, moths and butterflies visit many of the same flowers. A few kinds of insects and flowers have developed highly specialized relationships with each other. These flowers are pollinated only by a particular kind of insect. For example, bumblebees are the type of insect that pollinates the red clover flower.

Pollination by bees. More flowers are pollinated by bees than by any other kind of insect. Bees cannot see the colour red. Otherwise, they have a keen sense of sight. They also have a well-developed sense of smell. Bees are strongly attracted by yellow and blue flowers, especially those with a sweet odour. Unlike people, bees can see ultraviolet light. Many flowers, particularly yellow ones, have elaborate ultraviolet markings. These markings attract bees to the flowers and even pinpoint the location of the nectaries.

Many of the flowers pollinated by bees have a highly complicated structure that encourages cross-pollination and discourages self-pollination. For example, a bee can reach the nectar of a snapdragon only after brushing against the stigma. It then cannot leave the flower without touching the pollen. Furthermore, the bee cannot touch the stigma after it has touched the pollen.

Pollination by butterflies and moths. Butterflies and moths are attracted to flowers that produce abundant nectar. In many such flowers, the nectaries are long and tube-shaped or are at the base of a long tube-shaped corolla. Butterflies and moths have exceptionally long, tubelike mouthparts, which enable them to reach into these structures and suck up the nectar. Butterflies, like bees, prefer flowers with sweet-smelling yellow or blue blossoms.

Unlike most bees and butterflies, many moths rest during the day and search for food at night. Many of the flowers that attract moths open only at night. Most of these flowers are pale-coloured or white and so are easier to see at night than dark flowers. Many of the flowers are also heavily scented and give off their scent only at night. Flowering tobacco and various kinds of evening primroses and honeysuckles are some plants pollinated by moths.

Yellow flowers have ultraviolet markings that attract bees and indicate where nectar is produced. The human eye cannot see these markings, *left.* But when the flowers are photographed in ultraviolet light, *right,* dark areas appear that resemble the markings seen by bees.

Pollination by butterflies usually occurs with yellow or blue flowers that produce abundant nectar. Butterflies use their long mouthparts to reach into the flower and suck up the nectar.

The structure of a hibiscus helps prevent self-pollination. The yellow stamens are shorter than the pistils, making it unlikely for pollen from a stamen to reach a pistil.

The yucca flowers of the Southwestern United States are pollinated only by the yucca moth. The female moth carries pollen from one yucca plant to another. She bores into the ovary of the second flower and lays her eggs inside it. She then deposits pollen from the first flower onto the stigma of the second. The moth eggs and the yucca seeds develop together. The eggs hatch into caterpillars, which feed on the seeds. But enough seeds remain to produce the next generation of yuccas.

Pollination by beetles and flies. Beetles visit flowers in which both nectar and pollen are plentiful. They prefer white or dull-coloured flowers with spicy odours, such as magnolias and wild roses. Most flies do not have long enough mouthparts to suck nectar from tube-shaped flowers. These flies usually visit flowers with flat corollas, such as hawthorn blossoms and buttercups. Some flowers, such as carrion flowers and skunk cabbages, give off a foul odour that attracts flies.

Pollination by other agents. Some birds feed on nectar and so help pollinate flowers. Unlike most pollinating insects, birds have a weak sense of smell. But birds have sharp vision and see red as well as they see other colours. Most odourless red flowers are pollinated by birds. In the Americas, hummingbirds are the chief bird pollinators. Hummingbirds are particularly attracted to red and orange flowers, such as columbines and fuchsias. In Africa and Asia, the brilliantly coloured sunbirds are important pollinators of flowers. In Australia, birds called honeyeaters and parrots pollinate flowers, as do small marsupial mammals, such as honey possums and dormouse possums. Bats are important pollinators in the tropics.

The wind spreads the pollen of most plants whose flowers lack petals and sepals. These plants include oaks, ragweeds, sedges, and most wild grasses.

Self-pollination. Only a few species of plants normally pollinate themselves. Such plants include barley oats, peas, and wheat. However, when pollen falls onto a stigma of the same plant, self-pollination also occurs in species that normally depend on cross-pollination.

Self-pollination increases the chances of transmitting undesirable characteristics to the next generation. In some cases, the seeds produced by self-pollination may be unable to *germinate* (sprout). In some other cases, the seeds may develop into plants that cannot produce seeds of their own.

Self-pollination is impossible in dioecious species because the male and female flowers are on different plants. In addition, many other plants have characteristics that discourage or prevent self-pollination. In such flowers as hibiscuses and lilies, for example, the stamens are much shorter than the pistils. Any pollen that drops from the stamens is therefore unlikely to reach a stigma of a pistil on the same plant. A few plants, such as flowering tobacco and rye, have chemicals in their cells that prevent self-pollination.

Fertilization. A pollen grain that lands on a stigma may grow a *pollen tube.* The tube pushes its way down the style to an ovule in the ovary. Sperm from the pollen grain travel down the tube to the ovule. Fertilization occurs when a sperm unites with an egg cell in the ovule. A seed then begins to develop. The ovary develops into a fruit that encloses the seed. For an illustration of this process, see **Plant** (How flowering plants reproduce).

An ovary may be penetrated by many pollen tubes. But the number of seeds that develop depends on the number of ovules. An ovary with one ovule develops into a single-seed fruit, such as an acorn or cherry. An ovary with many ovules develops into a fruit with many seeds, such as a milkweed pod or watermelon.

Flower hobbies

Two of the most popular flower hobbies, outdoor and indoor gardening, are discussed in the article **Gardening**. This section deals with three other flower hobbies: (1) studying wild flowers, (2) flower arranging, and (3) flower breeding.

Studying wild flowers. To study wild flowers scientifically, you must be able to identify them. Various handbooks help provide such identification. Most of these books deal with the flowers of a particular region. The typical handbook divides the flowers into groups according to the colour of their blossoms. Each of these groups is then subdivided according to certain other characteristics of the plants, such as the number of their petals or the arrangement of their leaves. By checking a particular flower for each of the listed characteristics, you should be able to identify it. Many handbooks also provide an index of the scientific and common names of wild flowers.

One way to learn about wild flowers is to study them in their natural surroundings. For example, you might try to identify all the species in a particular environment, such as a meadow or woods. By taking careful notes and revisiting the location at various times of the year, you can produce a "biography" of the common flowering plants of that environment. Another way of studying wild flowers is by collecting them. However, you must follow certain rules in picking wild flowers. After you have picked the flowers, they must be properly preserved.

Rules for picking wild flowers. Unless rare plants are carefully protected in their natural surroundings, they may die out completely. For this reason, many countries have passed laws that prohibit people from picking wild flowers in public parks and forests. Such laws not only help conserve endangered species but also help preserve the blossoms so that more people can enjoy them in their natural environment.

In an area not protected by conservation laws, do not pick a specimen of a particular type of flower unless the species is plentiful in the area. As a general rule, wild flowers should never be uprooted.

Preserving wild flower specimens. The easiest way to preserve flower specimens is by pressing them. The method may be used to preserve not only the blossoms of wild flowers but also the entire plant, including the roots. While a specimen is still fresh, carefully arrange it between two sheets of newspaper. Then place the newspaper between two stacks of blotters or between the pages of an old phone book. Apply pressure by tying the blotters or phone book into a tight bundle or by using a weight. The pressure flattens the specimen and squeezes out the moisture. Change the newspaper wrapping daily and move the specimen to a dry part of the stack of blotters or phone book. After 7 to 10 days of pressing, the specimen should be dried out, unless it was especially juicy. Flowers can also be preserved using a *flower press,* in which they are held in sheets of paper between two flat pieces of wood that are clamped firmly together. The preserved specimen will last almost indefinitely if it is protected from moisture and insects.

Tape or glue each finished specimen to a sheet of heavy paper. Then label the mounted specimen with its

How to make a dried floral arrangement

Items suitable for making a dried floral arrangement include *left to right below,* okra pods, iris pods, silver dollar eucalyptus, eucalyptus, yellow statice, purple statice, yarrow, and safflower. The specimens should be dried in a dark, dry, well-ventilated room for about three weeks.

Select items of various shapes, sizes, and colours.

Dry your selections by hanging them upside down.

Arrange the items artistically in a suitable container.

common and scientific names, the place where the flower was found, the date it was picked, and any interesting facts about its growing habits. An organized collection of mounted pressed flowers is called a *herbarium.* See **Herbarium.**

Flower arranging. The ancient Egyptians, Greeks, and Romans all practised the art of making decorative arrangements of cut flowers. However, the art received its fullest development in Japan. The Japanese tradition of flower arranging dates from the 500's. At that time, Japanese Buddhists began to make floral arrangements in an elaborate style for the altars of their temples. Over the centuries, the Japanese refined and simplified this style and worked out its artistic principles. These Japanese principles have had a strong influence on the styles of flower arranging in many other countries during the 1900's.

The Japanese try above all to make each floral arrangement look natural, as if it were growing outdoors. They follow carefully worked out principles of design and colour to achieve this natural effect. The Japanese use leaves and stems as major elements in many arrangements. In Western countries, on the other hand, traditional styles of flower arranging tend to emphasize only the blossoms. Although Western principles of design and colour differ from those of the Japanese, they are just as important to the overall effect.

Most flower arrangements are made of fresh flowers. However, you can use dried flowers to make an attractive arrangement that will last longer than one made of fresh flowers. Flowers suited to drying include chrysanthemums, goldenrods, hydrangeas, larkspurs, and pearly everlastings. You can dry any of these flowers by hanging them head downward in a dark, dry, well-ventilated room for about three weeks. You can also dry various kinds of grasses and leaves in this way and then add the specimens to the flower arrangement. A dried floral arrangement that is prepared in late summer or autumn should last through the winter.

Flower breeding has become an increasingly popular hobby among gardeners. Each year, amateur gardeners in many countries produce hundreds of new varieties of flowers. Roses are especially popular for breeding, but many gardeners also work with such flowers as chrysanthemums, irises, orchids, and water lilies.

Most new varieties of flowers introduce changes in the colour, shape, size, or fragrance of the flowers. For example, breeding experiments have resulted in many dwarf varieties and numerous varieties with *double flowers.* Double flowers have more than the normal number of petals. Flower breeding has also produced such improvements as greater hardiness and greater resistance to diseases and insect pests.

Gardeners breed flowers by crossing two related species or two varieties of the same species. Each parent is selected for a desired characteristic, such as the colour or size of its blooms. The breeder takes pollen from one parent and places it on a stigma of the other parent. Some of the resulting offspring may have the desired characteristics of both parents. Such offspring are called *hybrids.* By repeating experiments with many parents and many varieties, gardeners can produce hybrids of greater vigour and beauty.

Japanese flower arrangers use design and colour to achieve a natural effect. On the left, an arranger trims branches to form graceful lines. In the finished arrangement, *right,* the branches emphasize one large flower. The size and shape of the vase balance the arrangement.

The naming of flowers. Flowers have both common names and scientific names. Many of the common names can be traced back hundreds or even thousands of years. The practice of giving plants scientific names began during the 1700's.

Common names. The common names of many wild flowers originated in folklore. In numerous cases, a plant's name comes from a traditional belief concerning the plant. People once used many wild plants as medicines and named the plants after the ailments they were thought to cure. For example, wild flowers named in this way include the North American agueweed and colicroot. People believed that agueweed cured a fever called the *ague* and that colicroot cured abdominal cramps called *colic.* In several other cases, a plant's common name simply describes a characteristic of the plant. For example, the flowers of lady's-slipper orchids resemble women's shoes. The leaves of pitcher plants form a pitcherlike shape. Rat's tail plantain has a flower spike similar in size and shape to a rat's tail.

The English names of many wild flowers end in -wort. Such flowers include birthworts, liverworts, milkworts, ragworts, and soapworts. The ending -wort comes from the Old English word *wyrt,* meaning *root* or *plant.* The first part of each name refers to some special characteristic of the plant, such as its appearance or supposed healing powers. For example, ragworts were so named because their leaves have extremely ragged edges. Birthworts provided a medicine that was believed to help women during childbirth.

The English names of many poisonous or supposedly poisonous wild flowers end in -bane. These flowers include cowbane, dogbanes, fleabanes, and henbane. The word ending comes from the Old English word *bana,* meaning *murderer.* The animal mentioned in each case was supposedly the one most affected by the poison. However, many of these plants, such as cowbane and most dogbanes, are also poisonous to other animals and to people. Some of the plants, including most fleabanes, are harmless.

The English names for many garden flowers can be traced back to Latin or ancient Greek. For example, the English name *lily* comes from the Latin name *lilium.* Peonies were called *paeoniae* in Latin, roses were *rosae,* and violets were *violae.* The English name *iris* comes from the Greek word *iris,* meaning rainbow. Hyacinths are named after Hyacinthus, a youth in Greek mythology famed for his great beauty. The names of some garden flowers come from languages other than Latin and Greek. For example, the name *tulip* comes from the Turkish word *tülbent,* meaning *turban.* Tulips are shaped somewhat like turbans and were introduced into Western countries from Turkey.

During modern times, a number of flowers have been named after people. For example, begonias were named in honour of Michel Bégon, a governor of French Canada and an amateur botanist. Dahlias were named after Anders Dahl, a Swedish botanist who introduced the flowers into Europe from Mexico. Poinsettias were named in honour of Joel R. Poinsett, a U.S. minister to Mexico, who introduced the plants into the United States from Mexico.

Scientific names. The common names of flowers are not suitable for scientific purposes. In many cases, the same flower has more than one common name. For example, a marsh marigold is also called a kingcup. In other cases, the same name is used for entirely different flowers. For example, several very different species of flowers are called bluebells in various English-speaking countries. To help avoid such confusion with names, botanists refer to each species of flower by its scientific name.

The Swedish botanist Carolus Linnaeus devised the modern scientific system of plant names in the mid-1700's. In this system, each species is given a two-part Latin name. The first part of the name refers to the *genus* (group of species) to which the particular species belongs. The second part of the name refers to the species itself. Each species has only one scientific name, and each name applies to only one species. For example, the flower known as a marsh marigold or kingcup has the scientific name *Caltha palustris.* The genus name, *Caltha,* means *gold-coloured flower* in Latin. The second part of the name, *palustris,* is a Latin word meaning *marsh loving.* No other species of plant in the world is named *Caltha palustris.* By using scientific names, botanists can identify every species of plant precisely and without confusion.

The scientific naming and the scientific classification of flowering plants are closely related. For example, newly discovered species must be classified according to genus before they can be given scientific names. However, every species keeps the second part of its name permanently, regardless of any changes that may later be made in the classification of the species. Thus, *Caltha palustris,* the marsh marigold, will always keep its specific name *palustris* even if it is someday reclassified into a different genus.

The classifying of flowers. Flowering plants make up the *division* (group) of plants called Anthophyta (from two Greek words meaning "flower" and "plant"). This division is split into two classes: (1) *dicotyledons,* also called *dicots,* and (2) *monocotyledons,* also known as *monocots.* Plants are grouped based on the structure of their seeds. The seeds of dicots have two tiny leaves called *cotyledons.* The seeds of monocots have only one cotyledon. In addition, the petals and other flower parts of most monocots grow in threes or in multiples of three, and the veins in their leaves parallel one another. The flower parts of most dicots grow in fours or fives or in multiples of four or five, and the veins in their leaves are branched rather than parallel. Of the approximately 250,000 species of flowering plants, about 190,000 are dicots and about 60,000 are monocots.

Each of the two classes of flowering plants is divided into *orders,* each order into *families,* and each family into *genera.* The table on the following three pages lists the families that include most well-known garden flowers and wild flowers. These families consist mainly of herbs and shrubs, but some also include trees. The table gives (1) the approximate number of species in each family; (2) typical characteristics of most flowers in the family; (3) the names of representative flowers; and (4) the general distribution of the family.

Representative families of flowers


African violet


Protea


Bellflower


Prickly pear


Boneset


Evening primrose


Gentian

Class Dicotyledonae

African violet family (Gesneriaceae)

About 2,000 species of perennial herbs and shrubs. The flowers have 5 sepals and 5 petals, fused into a tube, and 2 or 4 stamens. African violets, Cape primroses, gloxinias. Worldwide, mainly tropical.

Balsam family (Balsaminaceae)

About 600 species of annual or perennial herbs. The flowers have 3 to 5 sepals, 5 petals, and 5 stamens. One of the sepals forms a long, spur-shaped nectary at the back of the flower. Garden balsams, touch-me-nots. Found in temperate and tropical regions.

Banksia family (Proteaceae)

More than 1,000 species of perennial shrubs and trees. The flowers are irregular, with 4 sepals alternating with 4 scale-like petals. Banksias, Chilean fire bushes, golden pines, proteas. Central and South America, southern Africa, southern Asia, and Australia.

Begonia family (Begoniaceae)

About 900 species. Mostly perennial herbs and shrubs, with staminate and pistillate flowers on the same plant. The staminate flowers have 2 petallike sepals, 2 petals, and many stamens. The pistillate flowers have 2 or more sepals and a compound pistil. Begonias. Mostly found in the tropics.

Bellflower family (Campanulaceae)

About 1,950 species of annual or perennial herbs. The flowers of most species have 5 sepals, 5 petals, and 5 stamens. In most species, the petals are fused along most of their length, forming a bell-shaped corolla. Bellflowers. Mostly north temperate.

Borage family (Boraginaceae)

About 2,000 species. Mostly annual or perennial herbs, some shrubs, and small trees. The flowers of most species have 5 sepals fused at the base, 5 petals fused into a tubular shape at the base, and 5 stamens. Borage, forget-me-nots, heliotropes, lungworts. Centred on the Mediterranean region, but found in all temperate and subtropical areas.

Cactus family (Cactaceae)

About 2,000 species. Perennial herbs, shrubs, and trees. Most species have numerous petallike sepals and petals and many stamens. The sepals and petals are fused at the base. Cactuses. Native to dry areas of North, Central, and South America, widely introduced.

Coffee family (Rubiaceae)

About 7,000 species of annual and perennial herbs, shrubs, and trees. The flowers have 4 or 5 sepals, 4 or 5 petals, and 4 or 5 stamens. Coffee, gardenias. Mainly tropics.

Composite family (Compositae/Asteraceae)

More than 20,000 species. Mostly annual, biennial, or perennial herbs and shrubs. The flowers consist of several to many florets arranged on a head. Ageratums, asters, bonesets, calendulas, chicories, chrysanthemums, compass plants, cosmos, dahlias, daisies, dandelions, gaillardias, goldenrods, marigolds, sunflowers, thistles, zinnias. Worldwide.

Crowfoot or buttercup family (Ranunculaceae)

About 1,800 species. Mostly annual or perennial herbs. The majority have 5 petals—or 5 showy sepals in place of petals—and many stamens and pistils. Aconites, anemones, bugbanes, buttercups, columbines, delphiniums, hepaticas, larkspurs, marsh marigolds. Worldwide, but most widespread in the Northern Hemisphere.

Evening primrose family (Onagraceae)

About 650 species. Mostly annual or perennial herbs. The majority have 4 sepals, 4 petals, and 4 to 8 stamens. The sepals are fused, in many cases forming a long tube at the base of the flower. Evening primroses, fuchsias, godetias, willow-herbs. Found on all continents but most species from the southwestern United States.

Figwort or snapdragon family (Scrophulariaceae)

About 3,000 species. Mostly annual, biennial, or perennial herbs. Most species have 4 or 5 fused sepals, 4 or 5 petals fused at the base, and 4 stamens. Foxgloves, monkey flowers, mulleins, penstemons, slipperworts, snapdragons, toadflaxes. Mostly north temperate.

Gentian family (Gentianaceae)

About 800 species of annual, biennial, or perennial herbs. Most species have 4 or 5 sepals, 4 or 5 petals, and as many stamens as petals. The sepals are fused at the base, forming a cup-shaped calyx. The petals are fused into a tubular shape. Gentians. Worldwide.

Geranium family (Geraniaceae)

About 750 species of annual, biennial, or perennial herbs. Most species have 5 sepals, 5 petals, and 5 or 10 stamens. Crane's-bills, geraniums, pelargoniums. Worldwide.


Touch-me-not


Begonia


Forget-me-not


Coffee

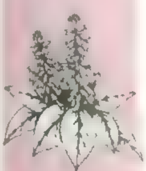

Buttercup

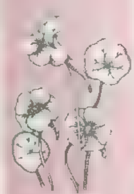

Snapdragon


Wild geranium


Heather


Tulip tree


Salvia


Nasturtium


Wild carrot


Garden pea


Periwinkle

Class Dicotyledonae (continued)

Heath family (Ericaceae)

About 3,000 species, mostly perennial shrubs and trees. The flowers have 4 or 5 sepals, and 4 or 5 petals, and 8 or 10 stamens. Blueberries, cranberries, heathers, heaths, rhododendrons. Worldwide, but absent from most of Australia.

Honeysuckle family (Caprifoliaceae)

About 450 species of perennial shrubs, small trees, and climbers. The flowers have 4 or 5 sepals, and 4 or 5 petals, fused into a tube. Elders, honeysuckles, snowberries, viburnums. Worldwide, except much of Africa.

Magnolia family (Magnoliaceae)

About 200 species of perennial shrubs and trees. The leaves are alternate and leave behind a clear scar when they fall. The flowers are large and usually grow at the ends of the branches. The petals are arranged in 2 or 3 whorls and the many stamens also grow spirally. Magnolias, tulip trees. Found in temperate and tropical Southeast Asia, North and South America.

Mallow family (Malvaceae)

About 1,500 species of annual, biennial, or perennial herbs, some shrubs and trees. The flowers have 5 sepals, 5 petals, and many stamens. The filaments of the stamens are fused, forming a tube around the pistil. Hibiscuses, hollyhocks, mallows. Worldwide, most species from South America.

Mint family (Labiatae/Lamiaceae)

About 3,000 species of annual and perennial herbs and shrubs. The 5 sepals and 5 petals are fused to form a tube. Coleus, deadnettles, lavenders, mints, salvias, thymes. Worldwide.

Mustard or cabbage family (Cruciferae/Brassicaceae)

About 3,000 species. Annual, biennial, or perennial herbs. The flowers have 4 sepals and 4 petals in the shape of a cross. Most species have 6 stamens. Candytuft, cresses, mustards, rockets, stocks, sweet alyssum, wallflowers. Worldwide.

Nasturtium family (Tropaeolaceae)

About 90 species of annual or perennial herbs. The flowers of most species have 5 sepals, 5 petals, and 8 stamens. One or more of the sepals forms a spur at the back of the flower. Canary creeper, nasturtiums. Native to Central and South America.

Nightshade family (Solanaceae)

About 2,600 species. Mostly annual or perennial herbs, some shrubs and trees. The flowers have 5 fused sepals, 5 petals fused into the shape of a star or funnel, and 5 stamens. Datura, deadly nightshades, ground cherries, henbane, petunias, tobaccos. Worldwide, with many kinds in South America.

Parsley or carrot family (Umbelliferae/Apiaceae)

About 2,900 species. Mostly biennial or perennial herbs. In most species, the flowers are small and arranged in umbrella-shaped clusters. The florets have 5 sepals, 5 petals, and 5 stamens. Cow parsley, hemlock, sweet cicely, water pennyworts, wild carrot. Worldwide.

Passion flower family (Passifloraceae)

About 600 species of annual and perennial herbs, shrubs, climbers, and trees. The flowers have 5 sepals, 5 petals, and 5 stamens. Passion flowers. Mainly tropical, mostly in South America and Africa.

Pea family (Leguminosae/Fabaceae)

About 17,000 species. Annual or perennial herbs, many shrubs and trees. The flowers of most species have 5 fused sepals, 5 petals, and 10 or many more stamens. Acacias, brooms, clovers, lupins, mimosas, redbuds, garden pea, sweet pea, wild indigos, wisterias. Worldwide.

Peony family (Paeoniaceae)

34 species of perennial herbs and shrubs. Large globular flowers with 5 to 10 large petals. Peonies. North temperate regions, especially Europe, China, and the northwestern United States.

Periwinkle family (Apocynaceae)

About 1,500 species of perennial herbs, climbers, shrubs and trees. The flowers are often fragrant and usually have 5 sepals forming a tube, and 5 petals. Periwinkles, oleanders, frangipani. Mostly tropical, especially in rainforests.

Phlox family (Polemoniaceae)

About 300 species. Mostly annual or perennial herbs. The flowers have 5 fused sepals, 5 petals, and 5 stamens. The petals are fused at the base. Phloxes, polemoniums. North and South America.


Honeysuckle


Marsh mallow


Mustard


Petunia


Passion flower


Peony


Phlox

Class Dicotyledonae (continued)


Maiden pink


California poppy

Pink family (Caryophyllaceae)

About 2,100 species. Mostly annual, biennial, or perennial herbs. The flowers of most species have 5 sepals, 5 petals, and 5 or 10 stamens. Campions, carnations, gypsophilas, pinks, sweet Williams. Found in North and South America, Europe, and Asia.

Poppy family (Papaveraceae)

About 250 species. Mostly annual or perennial herbs. The majority have 2 or 3 sepals, 4 petals, and many stamens. Bleeding heart, poppies. Temperate North America, Europe, Asia, South Africa, and eastern Australia.


Wild rose


Bermuda buttercup

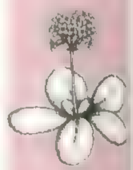
Rose family (Rosaceae)

About 3,200 species of perennial herbs, shrubs, and trees. The flowers of most species have 5 sepals, 5 petals, and numerous stamens. Agrimonies, apples, cherry laurel, cinquefoils, cotoneasters, hawthorns, mountain avens, pears, pyracanthus, raspberries, roses, spinosas. Worldwide.

Sorrel family (Oxalidaceae)

About 900 species of annual and perennial herbs. 5 sepals, 5 petals, and 10 stamens. Sorrels, Bermuda buttercup. Worldwide in temperate and tropical regions, except Australia.


Wood spurge


Kalanchoe

Spurge family (Euphorbiaceae)

More than 5,000 species of annual and perennial herbs, shrubs, and trees. Flowers usually have 5 petals, often with many stamens. Cassava, poinsettias, spurges, rubber trees. Worldwide, mostly tropical.

Stonecrop family (Crassulaceae)

About 1,500 species of succulent herbs and shrubs. Small flowers, mostly with 5 sepals and 5 petals, growing tightly packed together. Stonecrops, houseleeks, kalanchoes. Found particularly in South Africa, but species occur worldwide, except Australia and Southeast Asia.


Tea


Violet

Tea family (Theaceae)

About 1,000 species of perennial shrubs, vines, and trees. The often showy flowers have 4 to 7 sepals, 4 to 7 petals, and numerous stamens. Camellias, tea. Mainly tropical America and Asia.

Violet family (Violaceae)

About 850 species. Mostly perennial herbs and shrubs. The flowers have 5 sepals, 5 petals, and 5 stamens. In many species, the petal nearest the stem is larger than the others and has a hollow sac or spur at the back. Pansies, violas, violets. Worldwide.


Lotus

Water-lily family (Nymphaeaceae)

More than 90 species of perennial herbs. Water plants with floating leaves and flowers. The flowers have 3 to 6 green or coloured sepals, and 3 or many white or coloured petals. Water-lilies, sacred lotuses. Worldwide, in freshwater habitats.

Class Monocotyledonae


Daffodil

Amaryllis family (Amaryllidaceae)

About 1,300 species. Mostly perennial herbs. The flowers have 6 sepals and 6 stamens. All the floral parts, including the pistil, are fused at the base of the flower. Amaryllises, daffodils, jonquils, narcissuses, snowdrops. Worldwide.


Bird-of-paradise flower


Canna

Bird-of-paradise flower family (Strelitziaceae)

About 55 species of perennial herbs, and trees. The flowers have 3 sepals, 3 petals, and 5 stamens, and are enclosed in a colourful, boat-shaped leaf. Bird-of-paradise flowers, traveller's palms. Tropical South and Central America, South Africa, and Madagascar.

Canna family (Cannaceae)

About 55 species of large perennial herbs. The big flowers have 3 sepals, and 3 petals fused at the base. The stamens are petallike. Cannas, Queensland arrowroot. Central America and the West Indies.


Lily of the valley


Lady's slipper orchid

Lily family (Liliaceae)

About 4,000 species. Mostly perennial herbs. The flowers of most species have 6 sepals and 6 stamens. In some species the sepals are fused at the base. Aloes, day lilies, dogtooth violets, hyacinths, lilies, lilies of the valley, onion, Solomon's seals, trilliums, tulips. Worldwide.

Orchid family (Orchidaceae)

More than 20,000 species of perennial herbs with bilaterally symmetrical flowers. The flowers of most species have 3 petallike sepals, 3 petals, and 1 or 2 stamens, which are fused with the style. Orchids. Worldwide.

Related articles in *World Book* include:

Articles on individual flowers

World Book has hundreds of separate articles on flowering plants. Those that have showy blossoms and are not trees are listed below:

Flowers

Aconite
Adonis
African violet
Ageratum
Agrimony
Aloe
Amaranth
Amaryllis
Anemone
Arnica
Asphodel
Aster
Aubretia
Balsam, Garden
Bedstraw
Beggarweed
Begonia
Belladonna
Bindweed
Bird-of-paradise flower
Birdsfoot trefoil
Bitter root
Black-eyed Susan
Bladderwort
Bluebell
Boehmeria
Boneset
Bugbane
Buttercup
Butterwort
Calceolaria
Calendula
Calla
Campion
Candytuft
Canna
Canterbury bell
Cardinal flower
Carnation
Celandine
Chicory
Christmas bells
Christmas bush
Chrysanthemum
Cineraria
Cinquefoil
Clematis
Clover
Cocklebur
Cockscomb
Colchicum
Coltsfoot
Columbine
Compass plant
Coreopsis
Cornflower
Cosmos
Cowslip
Crocus
Cyclamen
Daffodil
Dahlia
Daisy
Dandelion
Day lily
Easter lily
Edelweiss
Elecampane
Evening primrose
Feverfew
Firecracker flower
Fleabane
Flowering tobacco
Forget-me-not
Freesia
Fritillary
Gaillardia
Gardenia
Gentian
Geranium
Gladiolus
Glasswort
Gloxinia
Godetia
Goldenrod
Goldenseal
Greenhood
Groundsel
Gypsophila
Hawkweed
Heather
Heliotrope
Hellebore
Hemlock
Henbane
Hollyhock
Hyacinth
Immortelle
Indian mallow
Indian pipe
Iris
Jack-in-the-pulpit
Jonquil
Kangaroo paw
Lady's-slipper
Larkspur
Lily
Lily of the valley
Lobelia
Loosestrife
Lotus
Lungwort
Lupin
Maidenhair fern
Mallow
Marigold
Marsh mallow
May apple
Mignonette
Monkey flower
Moonflower
Morning-glory
Mountain avens
Mullein
Narcissus
Nasturtium
Orchid
Oxalis
Pansy
Pasqueflower
Passionflower
Pelican flower
Peony
Petunia
Phlox
Pimpernel
Pink
Plantain
Poinsettia
Poppy
Portulaca
Primrose
Purslane
Pyrethrum
Rafflesia
Ragweed
Ragwort
Ramp
Ranunculus
Rose
Saint-John's-wort
Salpiglossis
Salvation Jane
Salvia
Saxifrage
Slipperwort
Snakeroot
Snapdragon
Snowdrop
Solomon's-seal
Sorrel
Spring beauty
Star-of-Bethlehem
Stock
Strawflower
Sturt's desert pea
Sunflower
Sweet alyssum
Sweet pea
Sweet William
Tansy
Thistle
Thrift
Tiger lily
Toadflax
Tuberose
Tulip
Valerian
Verbena
Vetch
Violet
Viper's bugloss
Wallflower
Water hyacinth
Water lily
Wild carrot
Wisteria
Wood anemone
Zinnia

Flowering shrubs

Acacia
Acanthus
Alder
Arbutus
Azalea
Banksia
Bay tree
Bayberry
Beach plum
Blackthorn
Boronia
Bougainvillea
Box
Broom
Buckthorn
Camellia
Cassava
Cranberry
Dogwood
Eglantine
Elder
Forsythia
Fuchsia
Furze
Gardenia
Grevillea
Hawthorn
Heather
Hebe
Hibiscus
Honeysuckle
Hydrangea
Jasmine
Jojoba
Laburnum
Lilac
Magnolia
Manzanita
Mock orange
Myrtle
Oleander
Passionflower
Plumbago
Potentilla
Privet
Pussy willow
Rhododendron
Spiraea
Sumach
Viburnum
Wattle
Wax myrtle
Wormwood
Yucca

Other related articles

Angiosperm
Botany
Breeding
Bulb
Caper
Dicotyledon
Duckweed
Floriculture
Fruit
Gardening
Gourd
Inflorescence
Liana
Monocotyledon
Perfume
Plant
Pollen
Seed
Shrub
Spice
Tree
Trefoil
Vine
Weed

Outline

I. The uses of flowers
- A. As decoration
- B. In landscaping
- C. Other uses

II. Garden flowers
- A. Garden annuals
- B. Garden biennials
- C. Garden perennials
- D. Garden perennials (Bulbs)
- E. Garden perennials (Flowering shrubs)

III. Wild flowers
- A. Flowers of the Arctic tundra
- B. Flowers of woodlands and forests
- C. Flowers of grasslands
- D. Flowers of scrub
- E. Flowers of alpine tundras
- F. Flowers of the desert
- G. Flowers of the tropics and subtropics

IV. The parts of a flower
- A. The calyx
- B. The corolla
- C. The stamens
- D. The pistils
- E. Variations in flower structure

V. The role of flowers in reproduction
- A. Cross-pollination
- B. Self-pollination
- C. Fertilization

VI. Flower hobbies
- A. Studying wild flowers
- B. Flower arranging
- C. Flower breeding

VII. How flowers are named and classified
- A. The naming of flowers
- B. The classifying of flowers

Flower arranging. See Flower (Flower hobbies).

Flowering maple or *abutilon* is the common name for about 90 kinds of herbs and shrubs that grow in temperate regions of Africa, Asia, and North and South America. Flowering maples usually have heart-shaped leaves. The flowers may be a wide variety of colours. They grow singly or in clusters.

Scientific classification. Flowering maples are members of the mallow family, Malvaceae. A common type is *Abutilon hybridum*.

Bright red and yellow blossoms of a flowering maple, or abutilon, *above*, contrast with the plant's dark-green leaves.

Flowering tobacco or *nicotiana* is the name of several annual and perennial plants in the nightshade family. They are grown for their sweet-scented flowers. The plants grow wild in tropical South America, and are cultivated in many areas.

The leaves of the flowering tobaccos are hairy and sticky. The flowers are yellow, purple, red, or white, and shaped like long tubes. The flowering tobaccos are sensitive to cold, and should be sheltered. They can be grown from seed in rich, light soil. The seeds should be planted in a hotbed or greenhouse in the early spring, and later transplanted outdoors.

Scientific classification. Flowering tobaccos belong to the nightshade family, Solanaceae, genus *Nicotiana*.

Flowering tobacco is grown for its sweet-scented flowers. It grows wild in warm climates, and is also cultivated.

Flowerpecker is a perching bird that lives from southern Asia to the Philippines and from Australia eastward to the Solomon Islands. Flowerpeckers are small birds whose basic colouring is brown or other dark colours. Some have bright red and yellow markings on their backs, breasts, and heads. They feed mainly on small berries, but also eat insects and nectar.

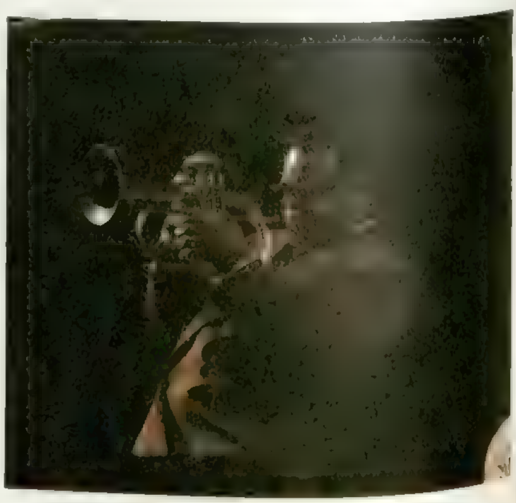
Scientific classification. Flowerpeckers belong to the songbird family, Dicaeidae.

Flu. See Influenza.

Flügelhorn is a brass musical instrument that resembles a large cornet and has the same general range of about $2\frac{1}{2}$ octaves. However, the flügelhorn is actually a member of the bugle family. A musician produces tones by blowing into a cup-shaped mouthpiece of the flügelhorn and vibrating the lips. The player changes notes by fingering the instrument's three valves and changing lip tension.

The flügelhorn has a mellow tone and a rich lower range. This makes it useful both as a solo instrument and as a link between the trumpet and the trombone when played in ensembles. The flügelhorn is most commonly used in popular music and in jazz. It is also played in brass bands.

Fluid is any substance that flows easily. A slight pressure or force will change the form of a fluid. But fluids are also elastic, so they tend to return to their former size when the pressure is removed. Fluids include all liquids and gases. Water at ordinary temperature is a fluid and a liquid. Air is a fluid and a gas. A liquid tends



Flügelhorn is most commonly used in popular music and in jazz. It has a more mellow tone than a trumpet.

always to occupy the same volume. A gas, however, readily changes its volume by expanding or contracting to fill, or fit into, any container in which it is placed.

Gases are compressible fluids and liquids are incompressible fluids. Pressure changes generally do not affect the density of a liquid (see **Density**). But in practice no liquid is completely incompressible.

A *perfect fluid* is frictionless—that is, it offers no resistance to flow except that of inertia (see **Inertia**). An *elastic fluid* has greater forces resisting changes to size or shape than forces resisting flow. A thicker, *viscous fluid*, such as molasses, is slow-flowing because of the fluid's internal friction.

See also **Hydraulics**; **Mechanics**.

Fluidic engine. See **Hydraulic engine.**

Fluke is any one of a large group of parasitic flatworms (see **Flatworm**). Flukes live in nearly every organ—including the intestine, liver, and lungs—of human beings and other animals. They also live in the blood. Most adult flukes are flat and leaflike, but some are round or long and wormlike. They have one or two suckers that hold them to body tissue in the *host* (animal in which they live). Most flukes have both male and female reproductive organs.

Flukes have complicated life cycles involving different stages of development and from two to four hosts. The first host is usually a snail, in which the young flukes multiply. Later stages of the fluke escape from the snail and enter fish, crabs, insects, or other animals. Some attach to plants.

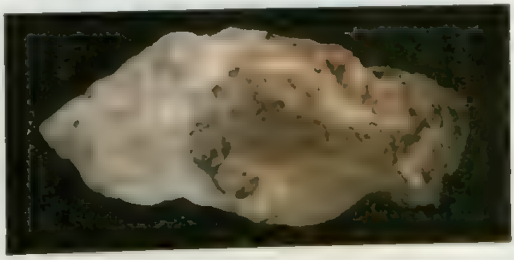
If a person eats an improperly cooked animal infected by flukes in their early developmental stages, the flukes may infect the person's body. The early stages of *schistosomes* (blood flukes) swim in water and burrow through the skin to reach blood vessels. The kinds of flukes that infect human beings are common in the Far East. Blood flukes are also common in tropical parts of the Western Hemisphere and in Africa. Blood flukes in humans cause a disease called *schistosomiasis*, or *bilharzia* (see **Schistosomiasis**).

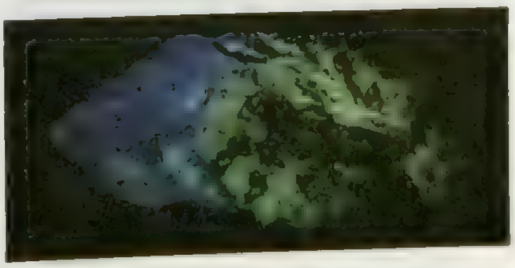
Scientific classification. Flukes belong to the subclass Digenea, class Trematoda, of the phylum Platyhelminthes. The liver fluke of human beings is *Clonorchis sinensis*, the lung fluke is *Paragonimus westermani*, and a common type of blood fluke is *Schistosoma mansoni*.

Flukes live in the blood and organs of human beings and other animals. Most adult flukes are flat and leaflike. The fluke above is a sheep liver fluke.

Fluorescence is a process by which a variety of substances give off light or another form of electromagnetic radiation when they absorb energy. The term *fluorescence* also refers to the light emitted by these substances. Many gases, liquids, and solids become fluorescent when exposed to radiation or to electrically charged particles.

Fluorescent lighting is widely used in factories, offices, and schools and in some homes. Some street lights contain fluorescent mercury vapour. TV picture tubes and electron microscopes have fluorescent screens. Biologists stain cells and tissues with fluorescent dyes to observe biological processes. Chemists detect certain air and water pollutants by using fluorescence. It also is used to detect lead poisoning and to identify minerals.





Fluorescence occurs when certain substances absorb energy and give off electromagnetic radiation. Ultraviolet rays cause the mineral, *top*, to give off blue and green light, *above*.

The colour of fluorescing light depends on the substance involved and on the type of energy absorbed. In most cases, the wavelengths of fluorescing light are longer than those of the absorbed radiation. However, fluorescence has been observed throughout the visible portion of the electromagnetic spectrum and also in its ultraviolet and infrared regions (see **Electromagnetic waves** [The electromagnetic spectrum]).

Many kinds of energy cause fluorescence. For example, electric current produces fluorescence in neon signs. Ultraviolet rays, visible light, X rays, and various other forms of radiation also cause fluorescence.

When a fluorescent substance absorbs energy, the electrons in its atoms become *excited*—that is, their energy level increases. In some cases, the electrons remain excited for only $\frac{1}{1,000,000,000,000}$ of a second. The excess energy is then emitted as light. The process stops when the energy source is removed.

Fluorescence was observed by scientists as early as the mid-1500's. It was first explained in 1852 by Sir George G. Stokes, a British physicist, who named it.

See also **Fluorescent lamp; Fluoroscopy; Luminescence; Phosphorescence.**

Fluorescent lamp is a tube-shaped electric light that has widespread use in factories, offices, and schools. In homes, incandescent lamps are more widely used than flourescent lamps. A fluorescent lamp uses only about a fifth as much electricity as an incandescent lamp uses to produce the same amount of light. It also produces only a fifth as much heat for the same amount of light. For this reason, fluorescent lamps are sometimes called "cool" lights. In addition, fluorescent lamps last much longer than incandescent lamps.

A fluorescent lamp consists of a glass tube containing a small amount of mercury vapour and another chemically inactive gas at low pressure. The gas in most fluorescent tubes is argon. The inside surface of the tube has a coating of chemicals called *phosphors* (see **Phosphor**). At each end of the tube is an electrode, a coil of tungsten wire coated with chemicals called *rare earth oxides*. A fluorescent circuit includes a device called a *ballast*, which provides voltage to start the lamp. The ballast also regulates the flow of current in the lamp circuit.

There are three main kinds of fluorescent lamp circuits: (1) preheat, (2) rapid-start, and (3) instant-start. Fixtures using a preheat circuit cost the least and are found in some homes. Rapid-start fixtures are more efficient than the preheat type, cheaper to operate and maintain, and widely used commercially.

When a preheat or rapid-heat lamp is turned on, electricity flows through the tungsten wire. The wire becomes heated, and the earth oxides on it give off electrons. Some of the electrons strike the argon atoms and *ionize* them—that is, the electrons give the atoms a positive or negative electric charge. When ionized, the argon can conduct electricity. A current flows through the gas from electrode to electrode, forming an *arc* (stream of electrons). Instant-start lamps start at such high voltage that the arc forms immediately. When an electron in the arc strikes a mercury atom, it raises the energy level of an electron in the atom. As this electron returns to its normal state, it emits invisible ultraviolet rays. The phosphors on the inside walls of the tube absorb the rays, which cause the phosphors to *fluoresce* (glow), producing visible light. The colour of the light produced depends on the phosphors used.

See also **Electric light; Fluorescence.**

Fluoridation is the addition of chemicals called *fluorides* to water supplies to help teeth resist decay. In the 1930's, researchers discovered that people who grew up where water naturally contained fluorides had up to two-thirds fewer cavities than people living in areas without fluoride in the water. In the United States, some cities began to fluoridate their water in 1945, as an experiment. By the 1950's, the tests showed that the incidence of tooth decay had decreased in these cities, and U.S. public health officials recommended fluoridation for all communities.

Today, more than half the people in the United States, Australia, and some other countries drink fluoridated water. The use of fluoride tablets and toothpastes and the application of strong fluoride solutions to the teeth by dentists can also help prevent tooth decay.

Benefits, risks, and costs. Many studies have shown that fluoridation reduces tooth decay substantially. However, large doses of fluorides can be harmful, especially to the bones and teeth. In India and other countries, for example, bone damage has occurred in people whose drinking water contained fluoride levels from 2 to 3 parts per million (ppm) or more. The level most commonly used in fluoridated water is 1 ppm. *Mottling* (discolouration) of the teeth becomes more common as the level of fluorides in drinking water increases. Even at the fluoride levels recommended for fluoridation, some people develop white flecks or patches on their teeth.

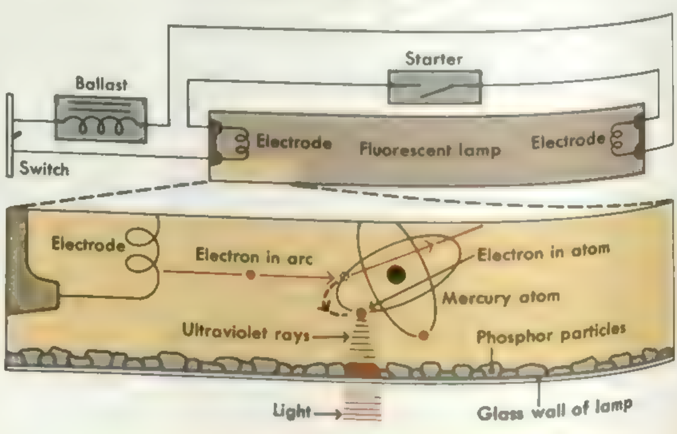
Some scientists believe that fluoridation involves special risks for people with kidney disease and for those particularly sensitive to toxic substances. However, ill effects from fluoridation have never been shown to be widespread. Most experts believe that the risk of harm from fluoridation is extremely small.

Public health officials and dentists in many countries favour fluoridation. They believe it provides important benefits and involves little or no health risk. Supporters also argue that fluoridation gives the whole community fluoride protection simply, effectively, and at a small expense compared with the costs of treating tooth decay.

Moral issues. Many people object to fluoridation because they prefer not to take any risks associated with it, even if the risks are very small. Some people feel they have a right to make their own choices in health matters, and that a community violates this right when it adds fluorides to its water supply. On the other hand, if water is not fluoridated, people will suffer tooth decay that easily

How a fluorescent lamp works

A preheat fluorescent lamp needs a *starter* and a *ballast* to operate. The starter switches electricity through the electrodes at each end of the lamp. The current heats the electrodes so they can give off electrons. Then the ballast sends a surge of current between the electrodes to form an *arc* (stream of electrons) in the lamp. The lamp contains mercury vapour. The arc knocks electrons in the mercury atoms out of their normal position. When the electrons return to their normal position, the atoms give off invisible ultraviolet rays. These rays strike phosphor particles on the walls of the lamp and cause the particles to glow.



could have been prevented. Many people feel that this result is also unacceptable. Fluoridation thus produces a conflict of moral beliefs for which there is no compromise solution.

See also Teeth (A good diet).

Fluoride. See **Fluorine; Fluoridation.**

Fluorine is a chemical element with symbol F. At ordinary temperatures, it is a pale yellow gas. Compounds that contain fluorine are called *fluorides*. Fluorine combines with other elements more readily than does any other element. It reacts even with noble gases such as xenon and krypton. With hydrogen, it forms a very strong acid that reacts with glass. Fluorine forms very strong chemical bonds with carbon atoms. This strong bond gives Teflon its unique properties. Teflon is a plastic material that consists of units of 2 carbon atoms and a fluorine atom. It is highly resistant against chemicals, corrosion, and oxidation; it resists temperatures up to 250° C; and it does not burn. Teflon is used in the manufacture of chemical processing equipment and for coating cooking utensils.

The principal source of fluorine is the mineral *fluorite,* also called *fluorspar.* Fluorite consists of the compound calcium fluoride (CaF_2). Steelmakers use fluorite to purify steel. Chemical companies treat fluorite with sulphuric acid to produce hydrogen fluoride (HF). Hydrogen fluoride is used to make aluminium and to produce compounds called *chlorofluorocarbons.* Chlorofluorocarbons serve as refrigerants in the cooling systems of refrigerators and air conditioners. Small amounts of fluorides applied to the teeth greatly reduce tooth decay. For this reason, fluorides are added to toothpaste, and many communities add fluorides to their drinking water.

Fluorine is the lightest of the elements known as *halogens* (see **Halogen**). Fluorine's atomic number is 9, and its atomic weight is 18.9984. Fluorine may be condensed to a liquid that boils at −188.14° C and freezes at −219.62° C. Fluorine was first isolated in 1886 by the French chemist Henri Moissan.

See also **Element, Chemical** (tables); **Fluoridation; Uranium** (Ability to form compounds).

Fluorite. See **Fluorspar.**

Fluorocarbon is any of a group of synthetic organic compounds that contain fluorine and carbon. Many of these chemicals also contain chlorine, and are called *chlorofluorocarbons* (*CFC's*). These compounds, often called *Freons,* have many uses. The two most commonly used fluorocarbons are *trichlorofluoromethane* ($CFCl_3$), also called F-11, and *dichlorodifluoromethane* (CF_2Cl_2), or F-12. They are used as refrigerants in air conditioners and refrigerators and to make plastic foams for furniture and insulation. See **Food, Frozen** (Liquid-CFC freezing).

F-11 and F-12 are nonpoisonous and nonflammable under normal conditions, and they are easily converted from liquid to gas or from gas to liquid form. These properties make the two chemicals useful as propellants in aerosol spray products (see **Aerosol**). However, scientific studies indicate that CFC's harm the environment by breaking down ozone molecules in the earth's upper atmosphere. Ozone, a form of oxygen, protects plants and animals from the harmful ultraviolet rays of the sun. As CFC's reach the upper atmosphere, ultraviolet rays cause them to break apart and release chlorine atoms. The chlorine atoms react with ozone and convert it to ordinary oxygen.

In 1978, the U.S. government banned certain fluorocarbon aerosols for most uses. In 1990, 56 nations agreed to end the production of CFC's by the year 2000. A 1992 agreement shortened the deadline to 1996. More than 100 nations have signed this agreement.

Fluoroscopy is a diagnostic medical procedure that uses X rays. It enables a doctor to view the internal structure and processes of the body. It produces an

A fluoroscope, *top,* enables doctors to view internal organs of the body while they function. The patient rests on a table with an X-ray tube beneath it. A large device called an *image intensifier* converts the X rays passing through the patient into an image that a doctor can view on a TV monitor. A doctor may also obtain a still picture, such as the fluoroscopic image of the stomach, *bottom.* The patient drinks a solution that causes the stomach and other organs to appear white in the image.

X-ray image of body organs actually functioning. It differs from *radiography,* a more common X-ray process that produces still images on film. Surgeons use fluoroscopy to view malfunctioning organs and to observe such medical procedures as the insertion of a *catheter* (tube) in an artery and the removal of foreign objects from the lungs or stomach.

Before a fluoroscopic examination of the digestive tract, the patient drinks a liquid containing a barium compound. Barium strongly absorbs X rays, and so the digestive organs show up more clearly in the image. The patient lies on a table. An X-ray tube is mounted beneath the table and a device called an *image intensifier* is suspended above the patient. X rays passing through the patient form an invisible image in the image intensifier. The image intensifier converts the X rays into a visible image that is recorded by a television camera. The doctor views this image on a TV monitor.

Fluoroscopy uses relatively low doses of X rays. As a result, the risk of undesirable side-effects is small. The American inventor Thomas A. Edison developed the first practical fluoroscope in 1896.

See also **Fluorescence; X rays.**

Fluorspar, also called *fluorite* or *fluor,* is a common mineral composed of calcium and fluorine. Its chemical formula is CaF_2. In rare cases, other elements may substitute for the calcium.

Fluorspar is important in the production of aluminium, steel, and hydrofluoric acid, a chemical used in manufacturing fluorine. Some lenses and prisms used in optical instruments consist of fluorspar.

Fluorspar crystals have a glassy lustre and are cubic or eight-sided in shape. Fluorspar may be transparent and colourless when pure. It also can occur in many colours because of defects in crystal structure or impurities. Fluorspar will often *fluoresce* (give off light) when exposed to ultraviolet radiation.

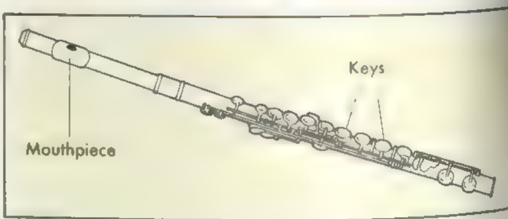
Fluorspar occurs widely in such rocks as granite, granitic pegmatite, syenite, and in ore veins. Fluorspar crystals may also line the cavity of spherically shaped, hollow stones called *geodes.* Major deposits of fluorspar are found in Canada, England, Germany, Mexico, and the United States.

See also **Fluorescence; Fluorine; Mineral** (picture).

Fluorspar crystals are cubic or eight-sided in shape.

Fluothane. See **Halothane.**

Flute is a woodwind instrument that serves as a soprano voice in many bands, orchestras, and woodwind groups. Most flutes are made of metal. They consist chiefly of a tube with a mouthpiece near one end. The mouthpiece has an oval hole. A musician holds the flute in a horizontal position and blows across the hole. At the same time, the player presses levers called *keys* that are positioned along the tube. The keys open and close *tone holes* to produce different notes and tones.



The flute is a woodwind instrument popular in bands and orchestras. A musician plays the flute by blowing across a hole in the mouthpiece and pressing keys that cover the tone holes.

The *concert flute in C* is the most popular flute. It has a range of three octaves. Other members of the flute family include the *piccolo,* the *alto flute,* and the *bass flute.* The piccolo resembles a small concert flute but is pitched one octave higher (see **Piccolo**). The alto flute is pitched a fourth lower than the concert flute. The bass flute is pitched an octave below the concert flute.

Wooden flutes were played in such countries as ancient Egypt, China, and Greece. They became widely used in Europe during the mid-1700's. In the early 1800's, Theobald Boehm, a German musician, developed the first cylindrical metal flute. Boehm also developed the system of keys and tone holes used in today's flutes.

Flux, in chemistry, is any substance that lowers the melting point of a substance to which it is added. A flux added to ore before melting helps to separate the impurities from the metal. In smelting iron, the flux used is generally limestone. This combines readily with the impurities to form slag, which can then be easily removed. Fluxes made of borax, soda, and potash are used to separate base metal from gold and silver. The term *flux* also refers to the rate of flow of matter or energy across a given surface. See also **Smelting.**

A house fly searches for food on a crust of bread. The stiff hairs on the fly's body and legs may carry many disease germs that brush off on anything the insect touches.

A horse fly's eyes break light into bands of colour.

The greenbottle is named after the colour of its shiny coat.

Fly is an insect with one pair of well-developed wings. The common house fly is one of the best known kinds of flies. Other kinds include bee flies, black flies, blow flies, bluebottles, bot flies, crane flies, deer flies, fruit flies, gnats, horse flies, hover flies, leaf miners, midges, mosquitoes, robber flies, sand flies, tsetse flies, and warble flies.

A number of other insects are often called flies, but they have four wings and are not true flies. These insects include butterflies, caddisflies, damselflies, dragonflies, mayflies, and scorpionflies.

Some flies are among the most dangerous pests known. They carry germs inside their bodies, on the tip of their mouthparts, or in the hair on their bodies. When a fly "bites," or when it touches any object, it may leave some of these germs behind. Flies carry germs that cause such serious diseases as malaria, sleeping sickness, filariasis, and dysentery. These insects also cause diseases in animals and plants.

Scientists have developed many ways to control flies. Some swamps are drained. Others are covered with oil or sprayed with insecticides. These treatments kill newly hatched mosquitoes and other flies that grow in water. Proper disposal of rubbish, decaying plants, and animal wastes is important for control of other kinds of flies.

Some kinds of flies are helpful. They carry pollen from one plant to another, much as bees do. Others eat insect pests. Scientists use fruit flies in the study of *heredity.* These flies have provided valuable information on how characteristics are passed on from one generation to the next.

Flies live throughout the world. Among the smallest are certain midges, which are found in forests and coastal marshes. They are about 1.3 millimetres long. One of the largest flies, the *mydas fly,* is found in South America. It is about 7.5 centimetres long and also measures about 7.5 centimetres from the tip of one wing to the tip of the other.

Flies are among the fastest of all flying insects. The buzzing of a fly is the sound of its wings beating. A house fly's wings beat about 200 times a second, and some midges move their wings about 1,000 times a second. House flies fly at an average speed of 7 kilometres per hour. They can fly even faster for short distances to escape from their enemies, which include people and many birds.

Facts in brief

Names: *Male,* none; *female,* none; *young,* maggots; *group,* swarm.
Number of newborn: 1 to 250 at a time, depending on species. As many as 1,000 a year for each female.
Length of life: Average 20 days in summer for house flies.
Where found: Throughout the world.
Scientific classification: Flies belong to the class Insecta, and make up the order Diptera.

There are about 100,000 kinds of flies. They make up an *order* (chief group) of insects. The scientific name of the order is *Diptera*, which comes from Greek words that mean *two wings*. This article provides general information about flies. To learn more about various kinds of flies, see the separate *World Book* articles listed in the *Related articles* at the end of this article.

The body of a fly

A fly's body has three main parts: (1) the head, (2) the thorax, and (3) the abdomen. The body wall consists of three layers and is covered with fine hair. Many kinds of flies have dull black, brown, grey, or yellowish bodies. A few kinds, including soldier flies and hover flies, may have bright orange, white, or yellow markings. Some kinds, such as bluebottles and greenbottles, are shiny blue or green. They seem to sparkle with brassy, coppery, or golden lights.

Head. A fly has two large eyes that cover most of its head. The males of some species have eyes so large that they squeeze against each other. The eyes of most female flies are farther apart.

Like most other kinds of insects, a fly has *compound* eyes made up of thousands of six-sided lenses. A house fly has about 4,000 lenses in each eye. No two lenses point in exactly the same direction, and each lens works independently. Everything a fly sees seems to be broken up into small bits. The insect does not have sharp vision, but it can quickly see any movement.

A fly has two antennae that warn it of danger and help it find food. The antennae grow near the centre of the head between the eyes. The size and shape of the antennae vary widely among different species of flies, and even between males and females of the same species. A house fly's antennae are short and thick; a female mosquito's are long and covered with soft hair; and a male mosquito's are long and feathery. The antennae can feel changes in the movement of the air, which may warn of an approaching enemy. Flies also smell with their antennae. The odour of the chemicals in rotting meat and rubbish attracts house flies. The odours of certain chemicals bring vinegar flies to wine cellars.

The mouth of a fly looks somewhat like a funnel. The broadest part is nearest the head, and a tubelike part called the *proboscis* extends downward. A fly uses its proboscis as a straw to sip liquids, its only food.

Flies do not bite or chew because they cannot open their jaws. Mosquitoes, sand flies, stable flies, and other kinds of "biting" flies have sharp mouthparts hidden in the proboscis. They stab these sharp points into a victim's skin and inject saliva to keep the blood from clotting. Then the flies sip the blood. Blow flies, fruit flies, and house flies do not have piercing mouthparts. Instead, they have two soft, oval-shaped parts called *labella* at the tip of the proboscis. The flies use these parts somewhat like sponges to lap up liquids, which they then suck into the proboscis. They sip liquids, or turn solid foods such as sugar or starch into liquids by dropping saliva on them.

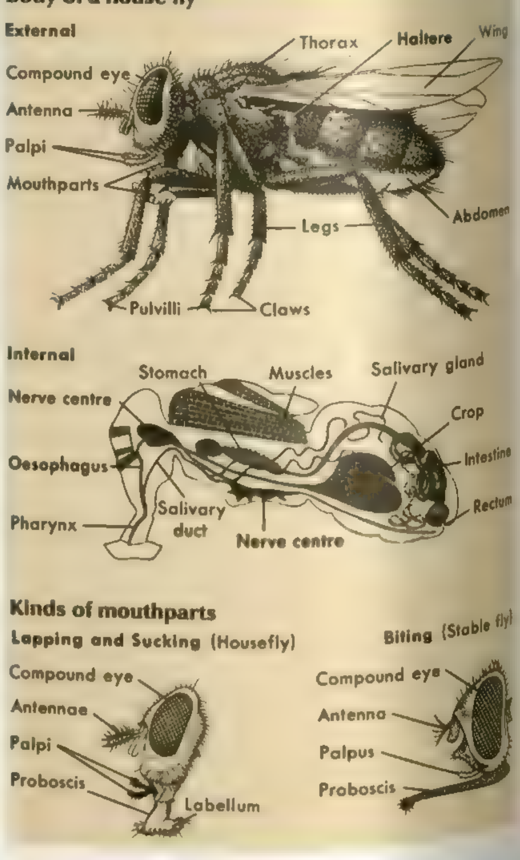
Thorax. A fly's muscles are attached to the inside wall of the thorax. These strong muscles move the insect's legs and wings. A fly has six legs. It uses all its legs when it walks, but often stands on only four legs. The legs of most kinds of flies end in claws which help them cling to such flat surfaces as walls or ceilings. House flies and certain other flies also have hairy pads called *pulvilli* on their feet. A sticky substance on the feet helps the insects walk on the smooth, slippery surfaces of windows and mirrors.

A fly's wings are so thin that the veins show through. The veins not only carry blood to the wings, but also help stiffen and support the wings. Instead of hind wings, a fly has a pair of thick, rodlike parts with knobs at the tips. These parts are known as *halteres*. The halteres give the fly its sense of balance. The halteres vibrate at the same rate as the wings beat when the insect is flying.

A fly is airborne as soon as it beats its wings. It does not have to run or jump to take off. In the air, the halteres keep the insect in balance and guide it so it can dart quickly and easily in any direction. A fly does not glide in the air or to a landing as do butterflies, moths, and most other flying insects. A fly beats its wings until its feet touch something to land on. If you pick up a fly, but leave the legs and wings free, the wings begin to beat immediately. Scientists sometimes do this with flies when studying wing movements.

Abdomen. A fly breathes through air holes called *spiracles* along the sides of its body. The abdomen has eight pairs of spiracles, and the thorax has two pairs. Air flows through the holes into tubes that carry it to all parts of the fly's body.

Body of a house fly



Life cycle of the house fly

Eggs Larvae Pupa Newly hatched adult

The life of a fly

A fly's life is divided into four stages: (1) egg, (2) larva, (3) pupa, and (4) adult. At each stage, the fly's appearance changes completely.

Egg. A female fly lays from 1 to about 250 eggs at a time, depending on the species. During her lifetime, one female may produce as many as a thousand eggs. The females of many species simply drop their eggs on water, on the ground, or on other animals. Some species stack the eggs in neat bundles.

At the tip of a female fly's abdomen is an organ called the *ovipositor,* through which the eggs are laid. The house fly usually places her ovipositor onto soft masses of decaying plant or animal material and lays her eggs there. One kind of mosquito arranges its eggs in groups that look somewhat like rafts. The eggs float on water until the larvae hatch.

The eggs of many kinds of flies are white or pale yellow, and look like grains of rice. A house fly's eggs hatch in 8 to 30 hours, but the time depends on the species of fly. Some kinds of mosquitoes lay their eggs during late autumn, but the eggs do not hatch until spring.

Some flies that spread disease

Fly	Disease	Host
Apple maggots	Bacterial rot	Apples
Black flies	Onchocerciasis (River blindness)	Human beings
Deer flies	Tularaemia (Rabbit fever)	Human beings, rodents
Fly maggots	Bacterial soft rot	Potato, cabbage, other vegetables
Horse flies	Anthrax	Human beings, animals
House flies	Amoebic dysentery	Human beings, animals
	Typhoid fever	Human beings
	Bacillary dysentery	Human beings
	Cholera	Human beings
Mosquitoes	Filariasis	Human beings
	Malaria	Human beings
	Yellow fever	Human beings, monkeys, rodents
	Dengue	Human beings
	Encephalitis	Human beings, horses
Olive fruit fly	Olive knot	Olives
Sand flies	Kala azar	Human beings
Tsetse flies	African sleeping sickness	Human beings

Larva of a fly is often called a *maggot.* The larvae of most kinds of flies look like worms or small caterpillars. They live in food, rubbish, sewage, soil, water, and in living or dead plants and animals.

A fly larva spends all its time eating and growing. It *moults* (sheds its skin and grows a new one) several times as it grows. The larval stage lasts from a few days to two years, depending on the species. The larva then changes into a pupa.

Pupa is the stage of final growth before a fly becomes an adult. The pupae of mosquitoes and some other kinds of flies that develop in water are active swimmers. Most pupae that live on land remain quiet. The larvae of some flies build a strong oval-shaped case called a *puparium* around their bodies. Black fly larvae spin a cocoon for protection. Inside, the larva gradually loses its wormlike look and takes on the shape of the adult fly. Then the adult fly bursts one end of the pupal case or splits the pupal skin down the back and crawls out.

The pupal stage of a house fly lasts from three to six days in hot weather, and longer in cool weather. The length of time varies among the different species.

Adult. When the adult emerges from the pupal case, its wings are still moist and soft. The air dries the wings quickly, and blood flows into the wing veins and stiffens them. The thin wing tissue hardens in a few hours or a few days, depending on the species, and the adult flies away to find a mate. About six generations of flies may hatch during summer.

A fly has reached full size when it comes out of the pupal case. A small fly grows no larger as it gets older, even though its abdomen may swell with food or eggs.

Adult house flies live about 21 days in summer. They live longer in cool weather, but are less active. Most adult flies die when the weather gets cold, but some hibernate. Many larvae and pupae stay alive during the winter. They develop into adults in spring.

Related articles in *World Book* include:

Bee fly
Blow fly
Bot fly
DDT
Deer fly
Disease (Spread of infectious diseases)
Filaria
Fruit fly
Gnat
Hessian fly
Horse fly
Insect
Insecticide
Leaf miner
Maggot
Mediterranean fruit fly
Midge
Mosquito
Sand fly
Tsetse fly
Warble fly

Fly is the largest river in New Guinea. For location, see **New Guinea** (map). The river rises in the Hindenburg Range and flows for more than 1,100 kilometres to the southwestern part of the Gulf of Papua. At its estuary, it widens to 53 kilometres. Small vessels can travel up the river for more than two-thirds of its length.

Fly, Artificial. See Fishing (Bait).

Flycatcher is the name of four different groups of birds. Between them they contain more than 700 species. Many flycatchers feed on flying insects, which they catch by darting out from a perch. The birds have flat bills, which they can open very wide. Generally, the bill is surrounded by bristles which help sweep the insects into the mouth.

The Acadian flycatcher belongs to the group of tyrant flycatchers. It breeds in North America.

Old World flycatchers are found in Europe, Africa, Asia, and Australia. There are more than 150 species. The European *spotted flycatcher* lives in open woodland, parks, and gardens. It often nests against a garden trellis set against a wall. The *pied flycatcher* is a woodland bird, especially of oak woods. It catches insects in the air, and will also take insects such as caterpillars from leaves. Australian flycatchers tend to have finer bills and catch their prey on the ground. Some Australian flycatchers are called robins (see **Robin**).

Monarch flycatchers live in Africa, India, Southeast Asia, and Australia. They have patches of glossy, irridescent plumage. Many types have a steep forehead with a slight crest, and coloured skin around the eyes. There are more than 100 species. The males of the *paradise flycatcher* have a 15 centimetre-long tail. Paradise flycatchers are generally chestnut, white, and black.

Fantail flycatchers live in India, Southeast Asia, and Australasia. They can spread their tail to form a fan, and wag it from side to side. There are about 38 species, including the Australian *willie wagtail.* Fantail flycatchers often feed high up in the tree canopy, making acrobatic displays in their chase for insects.

Tyrant flycatchers are the largest group of flycatchers, with over 400 species. They show a wide range of feeding habits. The largest are the 35-centimetre-long *shrike tyrants,* which drop onto prey, such as lizards and grasshoppers, on the ground. Other large flycatchers called *kiskadees* take tadpoles, frogs, and fish. Kiskadees have bold markings of black, yellow, and white. Some small tyrant flycatchers have wide spoon-shaped bills to scoop up insects from the underside of leaves. Tyrant flycatchers include *kingbirds* and *phoebes* (see Phoebe

Scientific classification. Most flycatchers belong to the family Muscicapidae. The spotted flycatcher is *Muscicapa striata* and the pied flycatcher is *Ficedula hypoleuca.* Paradise flycatchers are genus *Terpsiphone.* Fantail flycatchers are genus Rhipidura. The willie wagtail is *R. leucophrys.* Tyrant flycatchers belong to the family Tyrannidae. Shrike tyrants are genus *Agriornis,* kiskadees are genus *Pitangus,* kingbirds are genus *Tyrannus,* and phoebes are genus *Sayornis.*

Flying, in aircraft. See **Aviation.**

Flying buttress. See **Architecture** (Gothic).

Flying Doctor Service is an unusual medical service that originated in Australia. Through the service, people living in outback regions receive medical treatment and services. The service, officially known as the *Royal Flying Doctor Service,* maintains 12 major, centrally placed radio bases. They are located at Alice Springs, in the Northern Territory; Cairns, Mount Isa, and Charleville in Queensland; Broken Hill, in New South Wales; Port Augusta, in South Australia; and Kalgoorlie, Meekatharra, Carnarvon, Port Hedland, Derby, and Wyndham, in Western Australia. From these bases, doctors fly over 3 million kilometres a year.

Stations and homesteads in the outback have radio *transceivers* (units that can receive and transmit messages). In case of illness or the need to seek medical advice, people at the stations can make contact with the nearest radio base. A doctor at the base then advises the caller or arranges for an aeroplane to pick up the patient. Doctors make thousands of consultations over the radio each year. The Flying Doctor Service encourages people in remote areas to maintain standard medical kits so that they can carry out their own first aid. In addition, doctors make regular trips by plane around the area under their control. This area often covers a vast territory.

The Flying Doctor Service operates from 12 bases in Australia. Each base receives radio messages and flies medical service to the homesteads in the surrounding outback.

Flying Doctor Service brings medical supplies and medical help to people in the Australian outback.

In 1926, a South Australian engineer, Alfred Traeger, invented the *pedal wireless,* a radio using a dynamo powered by pedals. He later developed pedal power for transceivers. John Flynn realized that radio and aeroplanes together could extend medical facilities throughout Australia. In 1928, he founded the Flying Doctor Service with the help of Traeger. The first base was at Cloncurry, in Queensland. K. St. Vincent Welch became the first flying doctor. The first flight was made on May 15, 1928. In the first year of the service, he flew over 32,000 kilometres to treat 255 patients.

Flying dragon is the name commonly given to the so-called flying lizards of southeastern Asia and the East Indies. They grow to a length of about 20 centimetres. They do not really fly, but glide by means of folds of skin stretched over their ribs. Flying dragons live in trees and glide from tree to tree to search for food or to avoid their enemies. When resting, the lizards fold their "wings" against the sides of their bodies. During the mating season, the males spread their brightly coloured "wings" to attract females.

Scientific classification. Flying dragons are members of the Old World lizard family, Agamidae. They are genus *Draco.*

A flying dragon glides by spreading folds of skin.

Flying Dutchman is a ghost ship in folklore. There are many versions of the legend of the *Flying Dutchman.* The most common story involves the sighting of a phantom ship as it attempts to sail around the Cape of Good Hope in Africa. However, the captain has been cursed and his crew consists of dead men. The ship never reaches port and is doomed to sail on eternally. According to some versions of the legend, the curse resulted from an act of cruelty by the captain, perhaps aboard a ship carrying slaves. Other versions say he bargained with the Devil and lost.

The theme of the *Flying Dutchman* has been used in a number of literary and musical works. The English poet Samuel Taylor Coleridge based his poem "The Rime of the Ancient Mariner" (1798) on the legend. The German composer Richard Wagner adapted the story into his opera *The Flying Dutchman* (1843).

Flying fish. See Flyingfish.

Flying fox is a kind of large bat, not a fox. It lives in most tropical regions except South America. It is especially common in regions of the South Pacific. The head and body are about 30 centimetres long, and the wingspread may be over 1.5 metres. It gets its name from the fact that its face looks like that of a fox. The flying fox eats mostly fruit, and is more properly known as a *fruit bat.* It also feeds on flower buds, nectar, and pollen. It spends the day hanging in trees, often with other fruit bats. This may make the tree look as though it is loaded with fruit. Flying foxes can travel long distances for food. They can cause great damage to fruit orchards. See also **Bat.**

Scientific classification. Flying foxes make up the fruit bat family, Pteropidae. The Indian flying fox is *Pteropus giganteus.*

Flying lemur, or *colugo,* is a common mammal of Southeast Asia. It is about the size of a cat. Flying lemurs are not related to the true lemurs of Madagascar (see **Lemur**). Flying lemurs can glide as far as 90 metres from tree to tree, but they do not actually fly. Large folds of skin on the animal's sides connect its neck, legs, and tail. When it spreads its legs, this skin forms "wings" used in gliding.

Flying lemurs have a pointed face, large eyes, and brown or grey fur with white spots. They live in rain forests and eat tropical flowers, fruits, and leaves. Most fe-

The flying lemur does not actually fly. It has large folds of skin along its sides that connect its neck, legs, and tail. When the animal spreads its legs, this skin forms "wings" that are used in gliding from tree to tree, as shown above.

males give birth to one baby every year. Few zoos have flying lemurs, because it is hard to get their food.

Scientific classification. Flying lemurs make up the order Dermoptera. The order's single family, Cynocephalidae, has one genus, *Cynocephalus*. There are two species, *C. variegatus* and *C. volans*.

See also **Mammal** (picture).

Flying lizard. See **Flying dragon.**

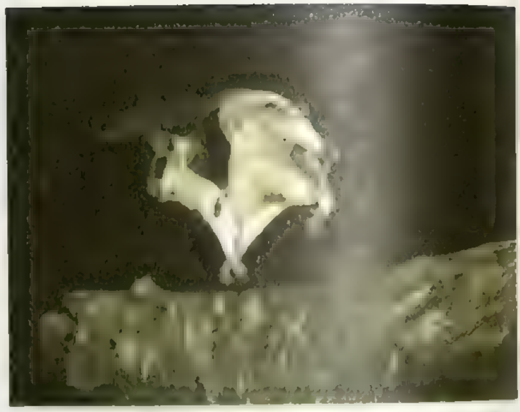
Flying Pieman was the nickname of William Francis King (1807-1874), a colourful character who lived in old Sydney. King was born in England, where he had a good education. Emigrating to New South Wales, Australia, in 1829, he held various jobs, including schoolteaching, before becoming a pieman. His amazing walking achievements earned him his nickname.

The Flying Pieman walked 2,629.7 kilometres in less than 6 weeks, including only 9 fine days. Twice he beat the coach from Windsor to Sydney—a 55-kilometre distance. On six consecutive days he walked from Sydney to Parramatta and back—48 kilometres each day.

King also walked the 70 kilometres from Parramatta to Windsor and back on three successive days. On other occasions, the Flying Pieman carried animals for wagers, such as a 42-kilogram goat plus 15.4-kilograms deadweight from Sydney to Parramatta in 7 hours.

Flying saucer. See **Unidentified flying object.**

Flying squirrel is a squirrel that can glide through the air. A fold of skin on each side of its body connects the front and back legs. When a flying squirrel stretches out its legs, the folds of skin form "wings." It glides from tree to tree, using its broad, flat tail to guide its flight. The squirrel's path is downward, then straight, and finally upward. Glides of more than 46 metres have been recorded. Flying squirrels always finish lower than where they started. A high starting point makes a long glide possible. Flying squirrels live in the forests of Asia, Europe, and North America. Most *species* (kinds) of flying squirrels are 20 to 30 centimetres long, including the tail. Their coat is grey or brownish-red on the upper parts and white or cream-coloured on the underparts.



The flying squirrel glides through the air by spreading its legs. Folded skin that grows between the legs stretches out to form "wings." The animal can glide more than 46 metres.

Giant flying squirrels live in southern and Southeast Asia. They are larger than their northern relatives, up to 60 centimetres long, and can glide for distances of over 100 metres. Scaly-tailed squirrels, a group of seven species of flying squirrels, live in West African tropical rain forest.

Flying squirrels nest in the hollows of trees. They hunt for food only at night. Other squirrels hunt by day. Flying squirrels eat berries, birds' eggs, fungi, insects, and nuts. They also eat young birds, as well as the meat of any *carcasses* (dead animals) they find. Female flying squirrels have from two to three young twice a year. By six weeks of age, young squirrels can "fly" on their own.

Scientific classification. Most flying squirrels belong to the squirrel family, Sciuridae, subfamily Petauristinae. The European flying squirrel is *Pteromys volans*. The common species in the eastern United States is the Southern flying squirrel, *Glaucomys volans*. Giant flying squirrels belong to the genus *Petaurista*. Scaly-tailed squirrels are in the family Anomaluridae.

Flyingfish is a type of fish that throws itself from the water with the motion of its strong tail. In the air, it glides by spreading its large fins, which act like wings. In "flight" the flyingfish vibrates its tail very rapidly. The long lower part of the tail fin dips in and out of the water and helps the fish stay up in the air.

There are about 50 different species of flying fish. They live near the surface of the sea and are widespread in the open oceans of the world, especially in the warmer regions. Flyingfish have streamlined bodies and grow up to 45 centimetres in length

The blackwing flyingfish is found in warm, but not tropical, seas, including the Mediterranean. It uses four large fins in flight. A common two winged flying fish is *Exocoetus volitans*. It lives in tropical seas, but may also be seen in the Mediterranean

Flying fish are good to eat. They are sometimes caught at night, using lights, to which they are attracted.

Scientific classification. Flying fish belong to the family Exocoetidae. The blackwing flyingfish is *Hirundichthys rondeletii*.

See also **Gurnard**; **Fish** (picture: Fish of coastal waters and the open ocean)

Flynn, Errol (1909-1959), an Australian-born American actor, became famous for his roles as a swashbuckling hero of adventure films. James Errol Leslie Flynn was born in Hobart, Tasmania. He studied at schools in Australia and England, and worked as a trader and prospector in New Guinea. He began his stage and film career in England, in 1934. In 1935, he went to the United States, where he starred as a romantic adventurer in a number of films. These include *Captain Blood* (1935), *The Charge of the Light Brigade* (1936), *The Adventures of Robin Hood* (1938), *The Sea Hawk* (1940), and *Gentleman Jim* (1942). Flynn's career was adversely affected by scandal, and his reckless life style had damaging effects on his health.

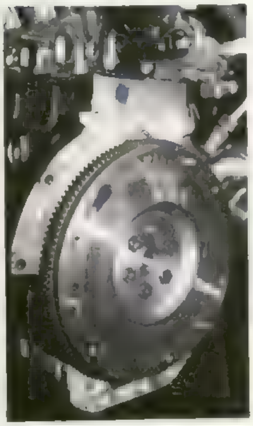
Flynn, John (1880-1951), was an Australian Presbyterian minister who gained worldwide fame for his work with the Australian Inland Mission and the Royal Flying Doctor Service. In 1912, he recommended that the Presbyterian Church extend medical and religious facilities to the remote areas of Australia. Following his recommendation, church authorities founded the Australian Inland Mission. Flynn was superintendent of the mission for almost 33 years. In that time, he founded 15 inland hospitals, and became known as *Flynn of the Inland.* With the advent of radio, Flynn had a means of overcoming the problem of long-distance communication in the outback. In 1928, he founded the Flying Doctor Service at Cloncurry, in Queensland. He was born at Moliagul, in Victoria. Flynn served as a Presbyterian minister from 1911.

John Flynn

Flytrap. See **Pitcher plant; Venus flytrap.**

Flyway. See **Bird** (Where birds migrate).

Flywheel is a heavy wheel attached to the shaft of an engine to keep its speed nearly constant. It is used where the forces driving the shaft are not constant. The driving forces in a petrol engine come from a series of explosions in the engine cylinder. These forces produce the power needed by the engine's load. Sometimes, the forces become momentarily larger than necessary for the engine's load, and the engine speed increases. The flywheel absorbs the excess energy and prevents the speed from increasing rapidly. At other times, the driving forces from the cylinder become momentarily smaller than necessary. Then the flywheel's inertia keeps the speed from decreasing quickly. The need for a flywheel decreases as the number of cylinders of a petrol engine increases. For example, less of the engine cycle energy must be temporarily stored by the flywheel with an eight cylinder engine than with a four cylinder engine.



A flywheel is attached to the shaft of an engine. It regulates the engine's speed.

See also **Petrol engine; Starter; Steam engine** (picture).

The flyingfish uses its tail to propel itself from the water into the air, where the fish's large fins aid in flight.

FM. See **Frequency modulation.**

Foam rubber. See **Rubber** (Sponge rubber).

Foch, Ferdinand (1851-1929), a French military leader, was acclaimed by many as the greatest Allied general of World War I. He became supreme Allied commander in April 1918, when a powerful German drive across France seemed on the verge of victory. Foch unified Allied operations and launched counterattacks that drove German forces back into Belgium. His final offensives won the war. At a meeting with Foch on Nov. 11, 1918, the German delegates signed the armistice that stopped the fighting.

Foch believed that a strong offence was the most effective way to fight a war. But he sometimes misjudged the effectiveness of German defensive firepower. He took part in disastrous offensives in August 1914 and led offensives that failed in 1915 and 1916. He was relieved of his command in December 1916. But Foch was able to learn from his failures.

Foch was born in Tarbes, France. He was commissioned in the artillery in 1874. He became a professor at the *École de Guerre,* the French war college, in 1895 and became head of the college in 1908.

Foch commanded an army corps at the outbreak of World War I and helped drive the Germans back from the Marne River in September 1914. From late 1914 to December 1916, he commanded the Northern Army Group. In 1917, Foch was made chief of the War Ministry's general staff and also served as intermediary between Henri Pétain, French commander in chief, and other Allied leaders. Foch was made marshal on Aug. 6, 1918, and was elected to the French Academy that year.

Ferdinand Foch

After the war, Foch urged Premier Georges Clemenceau to demand the Rhineland at the Paris Peace Conference in 1919. When the conference denied these demands, Foch bitterly predicted a new war would occur within 20 years.

See also **World War I** (The last campaigns).

Fodder is a coarse food fed to farm animals. Farmers make fodder from (1) grasses, including sorghum, cereals, and maize; (2) legumes, such as clover, alfalfa, beans, peas, and peanuts; or (3) roots, such as carrot, potato, turnip, and sugar beet. Fodder may be fed fresh, or may be dried. Farmers preserve fodder in *silos* for winter use.

Foehn is a warm, dry wind that blows down a mountainside. The air loses its moisture as it rises to the mountaintop. It is heated by compression as it comes down the other side of the mountain. Foehns blow frequently in the Alps, and along the eastern slope of the Rocky Mountains, where they are called *chinooks* (see **Chinook**). They also occur in North Africa, and are known as *ghibli* in Libya. These winds often bring rapid temperature changes.

Sudden foehns may cause snow to melt rapidly. They often affect the climate where they occur, making it much warmer than at neighbouring places.

Foetus is an alternative spelling of *fetus*. See **Baby** (The developing baby); **Pregnancy** (The baby during pregnancy).

Fog is a collection of tiny water droplets that float in the air. Fog is similar to clouds, except that clouds do not touch the earth's surface, as fog does.

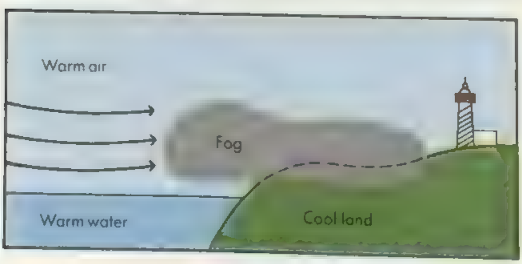
Fog forms from water that has evaporated from lakes, rivers, and seas, or from moist soil and plants. This evaporated water, called *water vapour,* expands and cools as it rises into the air. Air can hold only a certain amount of water vapour at any given temperature. This amount is called the *holding capacity.* As the temperature of the air decreases, so does its holding capacity. When the temperature drops so that the amount of water vapour in the air exceeds the holding capacity, some of the water vapour begins to *condense* (change into small droplets of water). Fog disappears when the air temperature rises and the holding capacity increases. According to international definition, fog is any condensation that reduces visibility to less than 1 kilometre. Fog that does not greatly reduce visibility is called *mist* or *haze.*

There are four main kinds of fog: (1) *advection fog,* (2) *frontal fog,* (3) *radiation fog,* and (4) *upslope fog.*

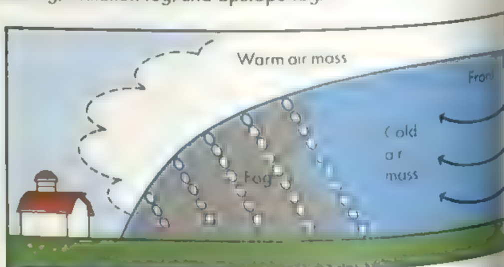
Advection fog develops from air travelling over a surface of a different temperature. One kind of advection fog, called *sea fog,* occurs when warm, moist air travels over a cold surface. Sea fog is most common along seacoasts and lakeshores. Another kind of advection fog, called *steam fog,* results from cold air passing over warm water. Water vapour, evaporating continuously from the water surface, comes into contact with the cold air. When the air reaches its holding capacity, the excess water vapour condenses quickly into fog droplets that steam up from the water surface. Steam fog commonly appears on cold winter days.

Frontal fog forms along a *front* (boundary between two air masses of different temperatures). Frontal fog is produced when raindrops fall from the warmer air mass into the colder one, where they evaporate. They thereby cause the water vapour in the cold air to exceed the air's holding capacity.

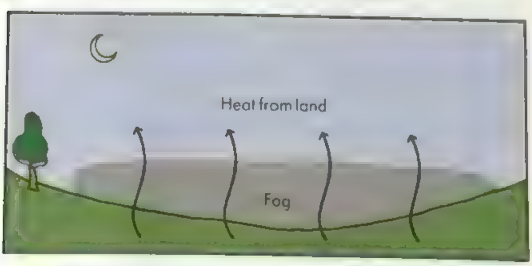
Kinds of fog Fog is a mass of tiny water droplets that are suspended in the air at or near the earth's surface. Fog, which reduces visibility, forms when water vapour in the air *condenses* (returns to liquid form). The four main kinds of fog are advection fog, frontal fog, radiation fog, and upslope fog.



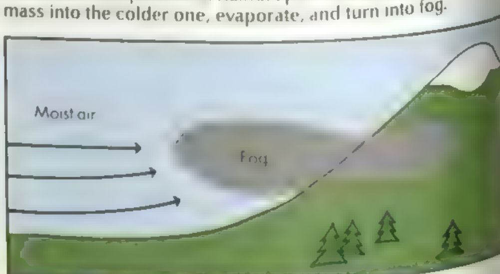
Advection fog occurs when warm, moist air travels over a cool surface, such as a seacoast or a lakeshore. It also may form when cold air passes over bodies of warm water.



Frontal fog develops on the boundary between two air masses of different temperatures. Raindrops fall from the warmer air mass into the colder one, evaporate, and turn into fog.



Radiation fog occurs at night, when the ground gives off heat through radiation. As the land cools, so does the air above it. Because this cooler air can hold less water vapour, fog is formed.



Upslope fog forms when moist air flows upward over a sloping land surface. As the air travels up the slope, it grows cooler. This cooling of the moist air produces fog

Radiation fog occurs on calm, clear nights as the ground loses warmth through radiation into the air. A layer of fog forms along the ground, gradually becoming denser.

Upslope fog develops when moist air moves upward along sloping terrain. The air cools as it moves up the slope until it can no longer hold the water vapour. Fog droplets then form along the slope.

See also Cloud; Dew; Smog; Water.

Foghorn. See Siren.

Foil. See Fencing.

Fokine, Michel (1880-1942), was a great Russian ballet dancer and *choreographer* (dance composer). Fokine invented the one-act ballet based on music by a first-rate composer. The dance and scenery in his ballets merge with the mood and drama of the music to create a powerful theatre event. Fokine composed more than 60 one-act ballets between 1905 and 1942. The best known include *The Dying Swan, Les Sylphides, Prince Igor, Scheherazade, Le Spectre de la Rose, Petrouchka, L'Epreuve d'Amour,* and *The Firebird.*

Fokine was born in St. Petersburg. There he became soloist with the Maryinsky Ballet (now the Kirov Ballet). He left Russia for Western Europe with Sergei Diaghilev's Ballets Russes in 1909. Fokine's early work with the Ballets Russes in Paris marked the beginning of his great career as a choreographer. He became a citizen of the U.S.A. in 1932.

See also Ballet (Russian ballet).

Fokker, Anthony Herman Gerard (1890-1939), was a Dutch engineer, pilot, and aircraft manufacturer. He moved to Germany at the age of 20, because of the interest in aviation there. He established his first manufacturing plant near Berlin when he was 22. Fokker designed monoplanes, biplanes, and triplanes. His factories supplied many aeroplanes for Germany in World War I. After the war, he set up plants in the Netherlands and the United States. Fokker was born in Kediri, Java.

Folger Shakespeare Library, in Washington, D.C., houses one of the most important collections of books on British civilization from about 1485 to 1715. It also owns the world's most important collection of books by and about William Shakespeare. The library has more than 225,000 volumes.

The library's rare books are protected in fireproof, air-conditioned vaults. An exhibition gallery, open free to the public, displays many rare books, pictures, and objects of interest from the Elizabethan period. The small theatre in the library is patterned after a typical playhouse of the period.

Henry Clay Folger, a former president of the Standard Oil Company of New York, founded the library in 1930. Folger left his entire fortune for the trustees of Amherst College to administer toward the development of a great research library. Scholars from all parts of the world come to the Folger Shakespeare Library for research in history and literature. The library building, a magnificent marble structure, was completed in 1932.

Folic acid. See Vitamin (table).

Folio is the name printers and publishers use for a sheet of paper folded once, making four pages, front and back. The word *folio* may also mean the page number of a book. Even-numbered pages, or folios, are always on the left. Odd-numbered folios are on the right side of a bound book or volume.

A *quarto* is a sheet folded twice, making four leaves or eight pages. An *octavo* is a sheet folded three times, making eight leaves or 16 pages. The octavo format, or shape of the book, is the one in most common use. But folio format or octavo format tells nothing about the *size* of a book today, although formerly it did. The size today depends on the dimensions of the sheet before it was folded.

Folk costume. See Clothing.

Folk dancing is the traditional form of dancing of a nation or ethnic group. Throughout history, almost every culture has developed its own folk dances. These dances have been passed down from generation to generation. People have composed *dance songs,* a type of folk music, to accompany many of the dances.

Most folk dances originated as a form of celebration, religious worship, or a method of controlling mysterious forces. The form and movements of many of these dances were based on superstitious beliefs. For example, a number of early folk dances were performed in a circle because people believed this shape had magical powers. In some early cultures, circular motion was thought to bring good luck or drive away evil.

Folk dancing is an important event at folk festivals throughout the world. The dancers shown on the left in traditional costumes are performing a German folk dance on Bavarian Folk Costume Day. This annual festival is held in Bad Wiessee, near Munich, Germany.

Early peoples developed dances to celebrate such events as birth, marriage, and even death. In some societies, young people conducted courtship through dances. The *Ländler* of Austria and the *fandango* of Spain are pantomime dances based on courtship gestures.

Other folk dances were originally performed to cure disease, to obtain such favours as plentiful crops, or to celebrate success in battle. The *tarantella* of Italy originated as a method of curing the bite of the tarantula. The Scottish *sword dance* celebrated victory in war. The English *morris dance* was originally a fertility dance. Specially trained teams of men or women still dance it today.

Over the years, most folk dances lost their original meaning and came to be danced chiefly for recreation. Today, most popular folk dances are the *square dance* of the United States and the *country dances* of the United Kingdom. These dances are performed by couples in various formations. The dancers swing about, bow, change partners, and perform other lively movements as directed by a caller. Popular European folk dances include the *Irish jig,* the *flamenco* of Spain, and the *polka* of Bohemia, a region in the Czech Republic. Among black African and American Indian groups, traditional dances remain a vital part of religious ceremonies, as well as a form of entertainment.

See the pictures of dancers in the following articles: **Greece; Indonesia; Romania;** and **Spain.** See also **Dancing; Latin America** (Dancing); **Square dancing.**

Folk literature. See Folklore; Literature for children (Folk literature).

Folk music consists of people's traditional songs or tunes. Many of the tunes were first used for dancing (see **Folk dancing**).

Most folk music has developed over very long periods. Some experts consider folk music to be only items composed by untutored people living in rural areas. Other experts use a broader definition, and also consider some of the songs that emerged in cities in recent times as true folk music. No one knows who composed most of the folk music in the world, but the authors of some modern pieces that are regarded as folk songs are known.

Folk songs deal with almost every kind of human activity. Most deal with love, jealousy, or war. Many express the political or religious beliefs of a people or group, or describe their history. Many others were originally sung as an accompaniment to hard physical work. Sea shanties and work songs come into this class. Still other folk songs, especially drinking songs, were made up to provide entertainment.

Songs made up by a known composer come to be considered folk songs if they become part of a people's traditions. Songs such as "Oh! Susanna" and "The Camptown Races", written by the U.S. composer Stephen Foster in the 1800's, are now widely regarded as folk songs. The song "Waltzing Matilda," written by the Australian Andrew Barton ("Banjo") Paterson in 1895, is now thought of as a folk song. Modern songs of protest, such as Bob Dylan's "Blowin' in the Wind," written in the 1960's, are also considered folk songs.

Most folk songs are ballads that tell simple stories and have simple words and music. Some ballads relate legendary incidents that occurred long ago. For example, "Barbara Allen" is a tragic love story that dates back at least to the 1600's. There are several versions of the song, some of which originated in England and others in Scotland. Some ballads are based on true events from more recent times. "Peat Bog Soldiers" describes the suffering of prisoners in Nazi concentration camps during the 1930's and 1940's.

The melody and words of a true folk song develop over a very long time. A made-up song is passed from person to person and from generation to generation. As new singers learn the song, they make slight changes to it. Over time, these changes can become quite dramatic. A tune can be changed so much that it sounds like a completely different tune. Sometimes, words and music become separated from each other, so that the words of one song might be sung to the music of another. The tune may even have originated in another country.

The music of a folk song is often simple and easy to memorize. Many songs of west European, American, or Australian origin have a simple verse structure, with the music repeated for each verse. These songs often have a chorus that is repeated between verses. Often, one person sings the verses and the audience joins in the chorus after each verse. A good example is an Irish song called "The Wild Rover" which has this chorus:

And it's no, nay, never,
No, nay, never no more
Will I play the wild rover,
No, never no more.

Sea shanties and work songs, such as "What shall we do with a Drunken Sailor," have many repeated lines. This makes them easy to learn as a background to a task.

Other societies have folk songs of a more complicated type. In some regions of India, poetic words are sung to an *improvised* (made up) tune using a melody based on a specific *rag* (scale). See **India, Dance and music of.**

In a type of music found in Wales called *penillion,* the singer performs poetry using an improvised tune that fits together with another tune that is a well-known traditional melody. This melody, which forms an accompaniment to the improvised tune, is called an *alaw.*

Folk singing can be very complex. Songs of eastern and central Europe often use unusual or intricate rhythmic patterns. In the countries of the Balkan Peninsula, choral folk singing is prominent. Duet folk singing, in which the performers sing the same music at the same time but keep one note apart, is well known in Yugoslavia. Folk singers may also use strange vocal techniques. In Mongolia, for example, some male singers use the throat and mouth to produce an accompanying melody while they sing. The accompaniment is made up of *harmonics* (partial frequencies of the note being sung).

Folk music for dancing is strongly rhythmical. Many dance tunes, including those of America, Australia, and western Europe, use a rhythm based on two, three, or four beats in a bar. Folk dances of central and eastern Europe, such as those of Hungary, Romania, and Albania, also use rhythms of five or seven beats in a bar.

Folk music instruments range from the simplest kind of flute or rattle to instruments such as the guitar or violin found in composed music. English morris dances, Irish jigs, and Scottish reels may be performed to the ac-

companiment of an accordion. The concertina and melodeon, small types of accordion, are also used.

Among the more unusual folk instruments are the cimbalom or dulcimer, a flat, four-sided stringed instrument from Hungary played with a pair of beaters, and the zither, a similar-shaped instrument plucked with the fingers and found in many countries. The Appalachian dulcimer and the autoharp are American developments of the zither. The didgeridoo is a wind instrument of the Australian Aborigines. It consists of a wooden tube about a metre long played by a person seated on the ground. The bagpipes, a form of wind instrument using an animal-skin bag as a bellows, are found in many countries, such as France, Spain, Ireland, and Italy, as well as Scotland and northern England. The traditional folk music of Java and Bali is famous for being played by *gamelan* orchestras. These are groups of musicians playing tuned gongs of different sizes and pitches.

Folk music's influence on other types of music has been very great. Some composers have studied and used themes and musical ideas from folk music to produce compositions that have a "nationalist" flavour. Such composers as the Norwegian Edvard Grieg, the Australian Percy Grainger, the Englishmen Frederick Delius, Gustav Holst and Ralph Vaughan Williams, the Hungarians Béla Bartók and Zoltán Kodály, and the American Aaron Copland were all great folk song collectors.

In America, traditional-style black African music taken there by slaves became the basis of blues and jazz, which in turn influenced pop music of the 1900's. Cajun music of Louisiana and the folk songs of the Appalachian Mountains are examples of regional folk music in America. Cowboy songs such as "I Ride an Old Paint" developed in the Wild West of the 1800's and gave way in the 1900's to country music (see **Country music**).

The systematic collection and study of folk songs began in the early 1900's with the work of Cecil Sharp in Britain and Bartók and Kodály in eastern Europe. In the United States, important scholars and collectors include Alan Lomax, B. H. Bronson, and Bruno Nettl.

In the 1960's, a folk revival with a strong protest element reached its height both in Britain and the United States. Leaders of the revival were the Americans Bob Dylan, Joan Baez, Judy Collins, Woody Guthrie, and Pete and Peggy Seeger, and British singers such as Ewan MacColl and the Waterson and Copper families.

Related articles in *World Book* include:

Baez, Joan	Dylan, Bob	Jazz
Ballad	Folk dancing	Latin America (Music)
Blues	Foster, Stephen Collins	Seeger, Pete
Calypso	Guthrie, Woody	Spiritual
Country music		

Folkestone. See **Kent** and **Shepway**.

Folklore is any of the beliefs, customs, and traditions that people pass on from generation to generation. Much folklore consists of folk stories, such as ballads, fairy tales, folk tales, legends, and myths. But folklore also includes arts and crafts, dances, games, nursery rhymes, proverbs, riddles, songs, superstitions, and holiday and religious celebrations.

Folklore is as old as humanity. Written records left by the earliest peoples include examples of folklore. As soon as a people develop a writing system, they begin to record folk stories. However, folklore does not have to be written down. Much folklore is passed orally from person to person. Even today, many peoples do not have a written language, but they have folk songs, legends, myths, and other kinds of folklore. Sometimes folklore is handed down by imitation. For centuries, children have learned games, such as skipping and marbles, by watching and imitating other youngsters

As people move from one land to another, they take their folklore with them and adapt it to their new surroundings. From the 1500's to the 1800's, for example, thousands of West Africans were transported to the Western Hemisphere as slaves. West African folk tales include stories about a sly spider named Anansi. Over the years, the slaves continued to tell tales of Anansi, though the stories about the spider were gradually changed to reflect life in the New World. Today, Anansi remains a popular character in black folklore, both in West Africa and in the Caribbean area.

Origins of folklore

During the 1800's, scholars believed that folklore in ancient times had been shared by all members of a society. Most ancient peoples lived in rural communities. Over the centuries, large numbers of people moved to cities and gradually lost touch with so-called "authentic" folk traditions. According to the scholars of the 1800's, those traditions were preserved by uneducated peasants called *folk*, whose way of life had changed little for hundreds of years. Two German brothers, Jakob and Wilhelm Grimm, were among the leading folklore scholars. From 1807 to 1814, they collected folk tales from peasants who lived near Kassel, in Germany. The Grimms believed that by collecting the tales, they were preserving for all time the heritage of all Germans. The stories they collected became famous as *Grimm's*

Detail of *Children's Games*, an oil painting on oak panel (1560) by Pieter Bruegel the Elder. Kunsthistorisches Museum, Vienna, Austria

Many children's games are handed down by imitation. For hundreds of years, youngsters have learned games by watching other children play. This painting of the mid-1500's shows boys and girls playing some games that young people of today enjoy.

Ethnic folklore preserves the customs of a par... tional or racial group. Americans of Swedish ancestry hold an annual festival in Minneapolis, Minnesota, U.S.A., that includes Swedish folk dances and songs performed in traditional costumes.

Fairy Tales. But some versions of these tales are found throughout Europe, the Near East, and Asia.

Today, scholars consider folk to be any group of people who share at least one common linking factor. This factor may be geography, as in folklore of the Ozark Mountains region of the United States; religion, as in Jewish folklore; occupation, as in cowboy folklore; or ethnic background, as in Irish-American folklore. Some scholars believe that even a family can be considered folk because many families have their own traditions and stories.

Characteristics of folklore

Folklore can be short and simple or long and complicated. Brief proverbs, such as "Time flies" and "Money talks," are famous examples of folklore. On the other hand, some Indonesian folk plays begin at sundown and end at dawn.

It is extremely difficult to make up folklore. The songs, stories, and other material that became folklore were, of course, thought up by various people. But those individuals had the rare ability to create a subject and a style that appealed to others over the years. Folklore survives only if it retains that appeal. People would not bother to retell tales or continue to follow customs that had no meaning for them. This is the reason people keep on using the same folklore over and over.

To be considered authentic folklore, an item must have at least two versions. It also must have existed in more than one period and place. For example, scholars have identified more than 1,000 versions of the fairy tale about Cinderella. These versions developed over hundreds of years in many countries, including China, France, Germany, and Turkey.

Changes in folklore often occur as a story passes from person to person. These changes, called *variations,* are one of the surest indications that the item is true folklore. Variations frequently appear in both the words and music of folk songs. The same lyrics may be used with different tunes, or different words may be set to the same music. The nursery rhymes "Baa, Baa Black Sheep" and "Twinkle, Twinkle Little Star" have the same melody. Some people use the folk saying "As slow as molasses," others "As slow as molasses in January," and still others "As slow as molasses in January running uphill."

Kinds of folklore

Myths are stories that explain how the world and humanity reached their present form. Myths differ from most types of folk stories because myths are considered to be true among the people who develop them.

Miniature (early 1300's) from the *Manesse Song Manuscript* by an unknown Swiss painter

Medieval folk musicians travelled throughout France and Germany. They often entertained royalty with long, elaborate songs that celebrated the heroic deeds of legendary kings and knights.

Many religious ceremonies include folk traditions. An American Navajo medicine man, *right,* and his helpers create a sand painting of a sun god for use in a ritual to treat a sick child. The painting design has been handed down by generations of medicine men.

Many myths describe the creation of the earth. In some of these stories, a god creates the earth. In others, the earth emerges from a flood. A number of myths describe the creation of the human race and the origin of death.

Folk tales are fictional stories about animals or human beings. Most of these tales are not set in any particular time or place, and they begin and end in a certain way. For example, many English folk tales begin with the phrase "Once upon a time" and end with "They lived happily ever after."

Fables are one of the most popular types of folk tales. They are animal stories that try to teach people how to behave. One fable describes a race between a tortoise and a hare. The tortoise, though it is a far slower animal, wins because the hare foolishly stops to sleep. This story teaches the lesson that someone who works steadily can come out ahead of a person who is faster or has a head start.

In many European fairy tales, the hero or heroine leaves home to seek some goal. After various adventures, he or she wins a prize or a marriage partner, in many cases a prince or princess. One popular kind of folk tale has a trickster as the hero. Each culture has its own trickster figure. Most tricksters are animals who act like human beings. In Africa, tricksters include the tortoise; the hare; and Anansi, the spider. The most popular trickster in North American Indian folklore is probably the coyote.

Legends, like myths, are stories told as though they were true. But legends are set in the real world and in relatively recent times.

Many legends tell about human beings who meet supernatural creatures, such as fairies, ghosts, vampires and witches. A number of legends are associated with famous people who have died. Others tell of holy persons and religious leaders. Some legends describe how saints work miracles.

The action in myths and folk tales ends at the conclusion of the story. But the action in many legends has not been completed by the story's end. For example, a legend about a buried treasure may end by saying that the treasure has not yet been found. A legend about a haunted house may suggest that the house is still haunted.

A number of legends tell about the Loch Ness Monster, a sea serpent in Scotland; and the Abominable Snowman, a hairy beast in the Himalaya. Some people believe these creatures actually exist. From time to time various expeditions have tried to find both of them.

Folk songs have been created for almost every human activity. Some are associated with work. For example, sailors sing songs called *shanties* while pulling in their lines. Folk songs may deal with birth, childhood

Black folk dances in America developed from West African religious dances. From the early 1600's to the mid 1800's, thousands of West Africans were transported to the Western Hemisphere as slaves. This water-colour painting of the late 1700's shows Southern plantation slaves performing a folk dance. Their musical instruments also originated in West Africa.

courtship, marriage, and death. Parents sing folk lullabies to babies. Children sing traditional songs as part of some games. Other folk songs are sung at weddings and funerals.

Some folk songs are related to seasonal activities, such as planting and harvesting. Many are sung on certain holidays. The folk song "The Twelve Days of Christmas" is a well-known carol. Some folk songs celebrate the deeds of real or imaginary heroes. But people sing many folk songs simply for enjoyment.

Superstitions and customs are involved largely in marking a person's advancement from one stage of life to another. For example, many cultures include a custom called *couvade* to protect unborn babies. In couvade, husbands pretend that they are about to give birth. They may avoid eating certain foods considered harmful to the expected baby. They also may avoid working because such activity could injure the unborn child.

A wedding custom called *charivari* is widespread in various European societies. On the wedding night, friends of the bride and groom provide a noisy serenade by banging on pots and pans outside the couple's bedroom. The desire to avoid charivari led to the practice of leaving on a honeymoon immediately after a wedding.

A large number of superstitions and customs supposedly help control or predict the future. The people of fishing communities may hold elaborate ceremonies that are designed to ensure a good catch. Many people try to foretell future events by analysing the relationships among the planets and stars.

Holidays are special occasions celebrated by a group, and almost all of them include some elements of folklore. Christmas is especially rich in folklore. A national group may celebrate this holiday with its own special foods and costumes. Many groups have variations of the same folk custom. In a number of countries, for example, children receive presents at Christmas. In Australia, the United Kingdom, and the United States, Santa Claus brings the presents. In Italy, an old woman named La Befana distributes the gifts. In some countries of Europe, the gifts come from the Christ child. In others, the Three Wise Men bring them.

Folklore and the arts

Folklore has made a major contribution to the world's arts. Many folk stories and folk songs are beautiful works of art themselves. Folklore has also inspired masterpieces of literature, music, painting, and sculpture. The English poet Geoffrey Chaucer used a number of folk tales in his famous *Canterbury Tales.* William Shakespeare based the plots of several of his plays on folk tales. These plays include *King Lear, The Merchant of Venice,* and *The Taming of the Shrew.*

Certain legends and myths have attracted artists, composers, and writers for centuries. One legend tells about a medieval German scholar named Faust who sold his soul to the devil. This legend has been the basis of many novels, plays, operas, and orchestral works. *Faust,* a drama by Johann Wolfgang von Goethe, is perhaps the greatest work in German literature.

Jazz developed largely from the folk music of Southern blacks in the Southern states of the U.S.A. Classical composers also have incorporated folk melodies into their works. For example, the Czech composer Antonín Dvořák used black spirituals in his famous symphony *From the New World.* The Austrian composer Wolfgang Amadeus Mozart used the melody of "Twinkle, Twinkle Little Star" as the basis of a work he wrote in 1778.

Folklore and society

Folklore reflects the attitudes and ideals of a society. For example, much folklore reflects how a society regards the roles of males and females in real life. In many examples of Western folklore, women are depicted as passive and uncreative. A society that produces such folklore considers men superior to women. This attitude appears in a proverb:

> A whistling maid and a crowing hen
> Are neither fit for gods nor men.

According to the proverb, a girl who whistles like a boy and a hen that crows like a rooster are unnatural. The proverb implies that women should not try to take part in activities traditionally associated with men, an idea that has become outdated in modern society.

A common wedding custom calls for the groom to carry his bride over the threshold of their home. This custom suggests that the woman is weak and must be carried through the doorway—and presumably through life—by the strong male. In many Western fairy tales, a female is captured by a villain and waits quietly until a heroic male rescues her.

Related articles in *World Book* include:

Kinds of folklore

Ballad
Dancing (Folk dancing)
Epic
Fable
Folk dancing
Folk music
Legend
Limerick
Mythology
Nursery rhyme
Proverb
Riddle
Romance
Saga
Superstition

American folklore and legend

Appleseed, Johnny
Bass, Sam
Billy the Kid
Boone, Daniel
Buffalo Bill
Bunyan, Paul
Carson, Kit
Crockett, David
Evangeline
Frietchie, Barbara
Henry, John
James, Jesse
Jones, Casey
Kidd, William
Laffite, Jean
Pecos Bill
Rip Van Winkle
Sacagawea
Smith, John
Song of Hiawatha
Standish, Miles

British folklore and legend

Allen, Barbara
Arthur, King
Beowulf
Brownie
Bruce, Robert
Brut
Davy Jones
Excalibur
Galahad, Sir
Godiva, Lady
Guy of Warwick
Holy Grail
Lancelot, Sir
Launfal, Sir
Loch Ness monster
Peter Pan
Rob Roy
Robin Hood
Round Table
Turpin, Dick
Whittington, Dick

German folklore and legend

Brunhild
Eulenspiegel, Till
Faust
Grimm's Fairy Tales
Lorelei
Mephistopheles
Munchausen, Baron
Nibelungenlied
Nix
Pied Piper of Hamelin
Siegfried
Tannhäuser

Irish folklore and legend

Banshee	Cuchulainn	Giant's Causeway
Blarney Stone	Finn MacCool	Shamrock

Folklore and legend of other lands

Abominable Snowman	Fountain of Youth
Aesop's fables	Gilgamesh, Epic of
Amadis of Gaul	Jack Frost
Arabian Nights	Mother Goose
Cid, The	Roland
Don Juan	Santa Claus
Edda	Tell, William
Flying Dutchman	Winkelried, Arnold von

Other related articles

Dragon	Moon (Mythology; legend and folklore)
Fairy	Storytelling
Gnome	Vampire
Literature for children (Folk literature)	Werewolf

Folkway. See Mores.

Follies are buildings and monuments of various kinds, generally erected purely as decorations. They include imitation castles and churches, arches, towers, pyramids, and even sham ruins. Many of them were built by wealthy landowners during the 1700's. In Britain, famous follies include Ralph Allen's castle, near Bath, in Avon; an Egyptian-hen-house at Tong, in Shropshire; and McCaig's Folly, at Oban, in Strathclyde Region. The earliest follies date from the 1500's.

Folsom point, a type of prehistoric spearhead, was the first evidence that human beings lived in North America during the Ice Age. A cowboy first discovered the stone points near Folsom, New Mexico, U.S.A., during the early 1900's. In 1926, scientists found the spearheads mingled with the bones of an extinct species of bison and identified the points as prehistoric weapons. The ancient bison disappeared about 10,000 years ago, at the end of the Ice Age. The discovery of weapons with the bison bones proved that people had migrated to North America by about 8000 B.C. Before the Folsom discovery, most scientists had believed that the first people reached the Americas more recently. Most scientists today think the spearheads are 10,000 to 11,000 years old. Folsom points have been discovered at other sites in the U.S. states of New Mexico, Colorado, and Texas.

Folsom points differ from later spearheads in that they have a long, thin shape rather than a triangular one. The points also have a long flake removed down the centre of one or both faces. The groove created by removing the flake is called a *flute,* and this type of point is called a *fluted* point.

See also **Indian, American** (The first Americans [picture: Spear points]).

A Folsom point is a long, thin prehistoric spearhead.

Fonda, Henry (1905-1982), was an American stage and film actor. He became famous for his portrayals of leading men of integrity and for his seemingly effortless acting style. Fonda appeared in more than 80 films. His most famous role was the title character in the comedy *Mr. Roberts,* which he played on both stage (1948) and screen (1955). He won the 1981 Academy Award as best actor for his performance in *On Golden Pond,* in which he co-starred with his daughter, Jane. He also received acclaim for his performances in *The Trail of the Lonesome Pine* (1936), *Young Mr. Lincoln* (1939), *The Grapes of Wrath* (1940), *The Lady Eve* (1941), *The Ox-Bow Incident* (1943), and *Twelve Angry Men* (1957). His son, Peter, is also a film actor and director.

Henry Fonda

Henry Jaynes Fonda was born in Grand Island, Nebraska, U.S.A. He first gained recognition for his performance in the Broadway revue *New Faces* (1934). He made his film debut in *The Farmer Takes a Wife* (1935). *Fonda: My Life* (1981) is his autobiography.

Fonda, Jane (1937-), is an American film actress. She has appeared in about 35 films, many of which she co-produced through her own company. Fonda won Academy Awards as best actress for her performances in *Klute* (1971) and *Coming Home* (1978).

Jane Seymour Fonda was born in New York City. She made her film debut in *Tall Story* (1960). Her other films include *A Walk on the Wild Side* (1962), *Cat Ballou* (1965), *Barbarella* (1968), *They Shoot Horses, Don't They?* (1969), *Julia* (1977), *The China Syndrome* (1979), and *The Morning After* (1987). In 1981, she co-starred with her father, Henry Fonda, in *On Golden Pond.*

Jane Fonda

Fonda is noted for her antiwar views and her work as a political activist. She has also become known for her physical fitness workout programmes.

Fontainebleau (pop. 15,679), a small city in northern France, is famous for a magnificent *château* (castle) that stands in a nearby forest. The city lies about 60 kilometres southeast of Paris. For the location, see **France** (political map).

King Francis I transformed a medieval castle into the château of Fontainebleau in the early 1500's. King Louis XIII, who reigned from 1610 to 1643, was responsible for much of its construction. French kings continued to add to and remodel the château as late as the 1700's. As a result, the structure displays a number of architectural and decorative styles. It has many paintings and elegant

The château of Fontainebleau is a famous French Renaissance palace. The structure is known for its diverse architectural styles, beautifully decorated interiors, and magnificent gardens.

carvings by the Italian artists Francesco Primaticcio and Fiorentino Rosso. The ballroom and the Francis I gallery feature especially impressive works of art. The château also has a small museum of Chinese art objects collected by Empress Eugénie, the wife of Emperor Napoleon III.

Many French kings used the château of Fontainebleau as a summer home. In 1814, Emperor Napoleon I gave up the throne of France at the château.

Fontane, Theodor (1819-1898), a German author, became known for his realistic and critical novels about Prussian society during the 1800's. Many of his works vividly portray the manners, morals, and social activities of the upper classes in Prussia. In his portrayal of characters and society, Fontane blends precise observation with humour, compassion, and irony.

Most of Fontane's stories take place in Berlin and the surrounding countryside. Most of his novels deal with personal conflicts of the chief characters, many of whom are women. Fontane's masterpiece, *Effi Briest* (1895), is a realistic yet sympathetic account of marital estrangement, adultery, and divorce. Several of his other novels also deal with love and marriage in a traditional, class-conscious society, including *Trials and Tribulations* (1888), *Beyond Recall* (1891), and *Jenny Treibel* (1892). He depicts the decline of the Prussian aristocracy in *A Man of Honour* (1883) and *The Poggenpuhl Family* (1896).

Fontane was born in the province of Brandenburg. He was almost 60 years old when his first novel was published. Before that time, Fontane was known as an author of ballads and travel books.

Fontanne, Lynn (1887-1983), was an American actress. She and her husband, Alfred Lunt, became the most celebrated acting team of their time. Fontanne was a sophisticated, glamorous, and accomplished performer. She was best known for her leading roles in *The Guardsman* (1924), *Strange Interlude* (1928), *Elizabeth the Queen* (1930), *Reunion in Vienna* (1931), *Design for Living* (1933), *The Great Sebastians* (1956), and *The Visit* (1958). Lunt was her co-star in all these plays except *Strange Interlude*. See **Lunt, Alfred**.

Lynn Fontanne

Fontanne was born near London, in England. Her first and middle names were Lillie Louise. She made her acting debut in 1905. She first visited America in 1910 and settled in the United States in 1916. She achieved her first major success in 1921 in *Dulcy*. In 1922, she married Alfred Lunt.

Fonteyn, Dame Margot (1919-1991), is generally considered to have been the greatest British ballerina of all time. Critics praised her precise technique and the warmth and delicacy of her style. Sir Frederick Ashton, a great English *choreographer* (dance composer), created many ballets for her, including *Daphnis and Chloe* and *Symphonic Variations*. Fonteyn gave perhaps her greatest performances in Ashton's *Ondine*. She and Ashton established a refined form of dancing that became known as the *British style*.

Margot Fonteyn was born in Reigate, England. Her real name was Margaret Hookham. When she was 14 years old, Fonteyn began dancing with the Vic-Wells Ballet (now the Royal Ballet) in London. In 1954, she became president of the Royal Academy of Dancing, also in London. In 1962, she began her partnership with the Russian-born dancer Rudolf Nureyev. They appeared in classical and modern ballets. She was named Dame Commander of the Order of the British Empire in 1956.

Dame Margot Fonteyn is often considered the greatest British ballerina of all time. In 1962, Fonteyn formed a partnership with Russian-born dancer Rudolf Nureyev, *shown with her above.*

See also **Ballet** (picture: *Swan Lake*).

Foochow. See Fuzhou.

An American family eating at a fast-food restaurant

A family in Senegal eating from a common bowl

Saudi Arabian men feasting on lamb and vegetables

A French couple lunching on cheeses and cold cuts

Food is a basic necessity of life. In addition, people everywhere enjoy eating. However, the kinds of food that people eat and how much food they have differ greatly around the world. There are also wide differences in the ways that people of various cultures prepare, serve, and eat food.

Food

Food is one of our most basic needs. We cannot live without it. Food gives us the energy for everything we do—walking, talking, working, playing, reading, and even thinking and breathing. Food also provides the energy our nerves, muscles, heart, and glands need to work. In addition, food supplies the nourishing substances our bodies require to build and repair tissues and to regulate body organs and systems.

All living things—people, animals, and plants—must have food to live. Green plants use the energy of sunlight to make food out of water from the soil and *carbon dioxide*, a gas in the air. All other living things depend on the food made by green plants. The food that people and animals eat comes either from plants or from animals that eat plants.

Food does more than help keep us alive, strong, and healthy. It also adds pleasure to living. We enjoy the flavours, odours, colours, and textures of foods. We celebrate special occasions with favourite meals and feasts.

Although all the food we eat comes from plants or animals, the variety of foods is incredible. Plants provide such basic foods as grains, fruits, and vegetables. Animals provide meat, eggs, and milk. These basic foods may require little or no preparation before they are eaten. Or they may be greatly changed by processing. For example, milk may be made into such foods as butter, cheese, ice cream, and yoghurt.

The chief foods that people eat differ widely throughout the world. Millions of people in Asia eat rice as their main food. People of the Pacific Islands depend heavily on fish. Most people of Turkey eat mainly cracked-wheat bread and yoghurt. The people of Argentina and Uruguay eat a lot of beef. What people eat depends chiefly on where they live and on how much money they have. It also depends on their customs, health, life style, and religious beliefs. Children learn many eating habits from their parents. But each person develops individual food preferences and prejudices. Eating habits are also influenced by how much time people have to buy, prepare, and eat food.

In developing countries of Africa, Asia, and Latin America, many families must produce all their food themselves. In the industrialized countries, however, most people rely on the *food industry* for their food. The food industry includes farmers, food-processing companies, researchers, shipping companies, and food stores. The growth of the food industry has greatly increased the amount and kinds of foods available in industrialized countries.

The supply of food has always been one of the major concerns of the human race. In many areas of the world,

A Japanese family dining at a beautifully set table

Indians of Ecuador snacking on beans and maize

millions of people go hungry and many die of starvation. Food shortages and famine result from crop failures, natural disasters, increasing desertification, overpopulation, wars, and other causes. For detailed information about food supply problems, see the articles **Food supply** and **Famine**.

Sources of food

Plants supply much of the food people eat. In many African, Asian, and Latin-American countries, the people depend on plants for more than two-thirds of their food. In Australia, Europe, North America, and parts of South America, the people eat a lot of meat. But even in these areas, over half the diet consists of food from plants.

Some basic foods, including eggs, fruits, and vegetables, are commonly sold in their natural state. Most other foods are processed in manufacturing plants before they reach the market. All canned, dried, frozen, and pickled foods are processed. Processors also produce baked goods, frozen dinners, and many other *convenience foods,* which save work for the cook.

Food from plants. The most important foods that are obtained from plants are (1) grains and (2) fruits and vegetables.

Grains, also called *cereals,* are the seeds of such plants as barley, maize, millet, oats, rice, rye, sorghum, and wheat. The human diet has been based on grains for thousands of years. Rice or a grain product, particularly bread, is the main food in many cultures. Millers grind much of the world's grain, especially wheat, into flour. Wheat flour is used in almost all breads, in pastries, and in pasta and various kinds of noodles. Processors also make breakfast cereals from grains.

Fruits and vegetables add a variety of colours, flavours, and textures to the diet. People enjoy fruits for their sweet or pleasantly sour flavour. Popular fruits include apples, bananas, cherries, melons, oranges, peaches, pineapples, and strawberries. Most fruits are eaten as snacks or in a salad or dessert.

Favourite vegetables include beans, broccoli, cabbage, carrots, celery, lettuce, onions, peas, potatoes, sweet corn, and tomatoes. Vegetables are commonly eaten during the main part of a meal. They may be served raw in a salad, cooked and served with a sauce, or added to a casserole or soup.

Other foods from plants include nuts, herbs and spices, and beverages. Coffee, cocoa, tea, and many other drinks are made from plants. Nuts are popular snacks and can be used as flavourings in other foods. Cooks also use herbs and spices to flavour foods.

Food manufacturers use plant materials to make cooking oils, sugar, and syrups. They also use plants to

Interesting facts about food

Dumplings are eaten in various forms around the world. Chinese *won ton,* Italian *ravioli,* Jewish *kreplach,* and Polish *pierogi* are types of dumplings filled with meat, cheese, or vegetables.

Frankfurters were named after Frankfurt, Germany. Experts believe these sausages were first made in Germany during the Middle Ages. About 1900, an American vendor selling cooked frankfurters supposedly called them "hot dachshund sausages" because they resembled the long-bodied dog. Later, the term *hot dog* came to be used.

Hamburger was originally called *Hamburg steak.* It was named after Hamburg, Germany.

Hundred-year-old eggs, a delicacy in China, are preserved duck eggs. They are cured in the shell for about six months in a mixture of ashes, lime, salt, and tea. The curing makes the eggs taste like cheese.

Ice cream cones were first served at the St. Louis World's Fair in 1904. A thin, crisp waffle was rolled into a handy holder for a scoop of ice cream.

Pancakes are probably the oldest prepared food. The first pancakes were a mixture of pounded grain and water spread on a hot stone. Today, people enjoy such pancake variations as French *crepes,* Hungarian *palacintas,* Indian *dosai,* Italian *cannelloni,* Jewish *blintzes,* and Russian *blini.*

Pavlova is a meringue dessert topped with whipped cream, created in honour of the Russian ballerina Anna Pavlova, who visited Australia and New Zealand in the 1920's. Both Australia and New Zealand claim to have invented it.

Pizza, an international favourite, originated in Italy. *Pizza* is the Italian word for *pie.*

Pretzels were first made by monks in southern Europe as a reward for students who learned their prayers. The crossed ends of a pretzel represent praying hands.

Raw fish is a favourite food of many people. The Japanese enjoy *sashimi,* thin slices of raw seafood. *Seviche* is a popular Latin-American appetizer of raw fish in lime juice. Swedes prepare *gravad lox,* fresh salmon with dill.

Sandwiches were named after the Earl of Sandwich, an English nobleman of the 1700's. While playing cards, he ordered a servant to bring him two slices of bread with a piece of roast meat between them.

The variety of foods is amazing. This picture shows a few of the products—breads, breakfast cereals, macaroni, pancakes, pastries, and snack foods—that can be made from wheat.

make synthetic foods. For example, they make foods that look and taste like meat from soybeans. They make non-dairy creamers from vegetable fats.

Food from animals includes (1) meat, (2) eggs, and (3) dairy products. These foods cost more to produce than do foods from plants. As a result, foods from animals are eaten more in developed countries than in developing ones.

Meat consists mainly of the muscle, fat, and other parts of an animal's body. The word *meat* most commonly means the red meat of cattle, pigs, sheep, and game animals. However, the flesh of fish and poultry is also considered meat.

Popular red meats include beef and veal from cattle, pork from pigs, and lamb and mutton from sheep. Many people also enjoy such meats as kidney, liver, and tongue. Favourite fish include cod, perch, salmon, trout, and tuna. Clams, crabs, lobsters, oysters, prawns, scallops, and shrimp are favourite shellfish. The most popular kinds of poultry are chicken, duck, goose, and turkey. In some countries, people enjoy the meat of caribou, goats, horses, monkeys, rabbits, or snakes. They might also eat ants, grasshoppers, snails, turtles, or certain other animals.

Much poultry is marketed as the whole animal. Many other meats are sold as *cuts,* such as chops and steaks. Ham and corned beef are *cured* (preserved) before being marketed. Meats are also processed into such products as sausages, paté, and cold cuts. Meat is commonly eaten during the main part of a meal.

Eggs. Farmers raise poultry, especially chickens, for their eggs as well as for their meat. Chicken eggs are popular as a breakfast or supper dish, or they can be used in custards and other cooked dishes. The eggs of certain kinds of fish are used to make a delicacy called *caviar.* In some countries, people enjoy the eggs of such birds as emus, gulls, or penguins. People of various countries also eat the eggs of alligators, crocodiles, or certain other reptiles.

Dairy products are important foods in many cultures. Cows provide most of the milk used in many countries. But such animals as camels, goats, reindeer, or sheep supply milk in some parts of the world. Milk and milk products are marketed in many forms. In addition to whole milk, people can buy buttermilk, skimmed milk, low-fat milk, and condensed, dried, and evaporated milk. Other dairy products include butter, cheese, cream, ice cream, sour cream, and yoghurt.

How the body uses food

Food supplies the *nutrients* (nourishing substances) that the body needs for (1) producing energy, (2) building and repairing tissues, and (3) regulating body processes. The main kinds of nutrients are carbohydrates, fats, proteins, minerals, and vitamins. Each kind of nutrient plays an important role in keeping the body healthy. Many foods are highly nourishing, but no one food supplies every necessary nutrient.

As the body digests food, the food is broken down into the various nutrients. The food eventually enters the small intestine, and the nutrients pass through the intestinal wall into the bloodstream. The blood distributes the nutrients to cells throughout the body.

In addition to nutrients, food supplies other important substances, especially water and fibre. The water in food helps dissolve nutrients and helps carry them to body cells. Water also helps carry waste products from the cells and out of the body. Fibre does not break down during digestion. Instead, fibre adds bulk to food and keeps it moving through the intestine.

People who do not get enough food to eat suffer from *undernutrition.* A person whose diet seriously lacks any nutrient is said to be *malnourished.* Some malnourished people have plenty of food available to them, but they choose to eat foods that do not supply all the necessary nutrients. Some people develop health problems because they eat too much and become overweight.

A moderate, well-balanced diet can help ensure good health. For detailed information about the foods that contribute to a healthful diet, see **Nutrition.**

Producing energy. One of the most important ways in which the body uses food is to produce energy. The proteins in food can be used to provide energy. But carbohydrates and fats serve as the major energy sources. Carbohydrates are the starches and sugars in food. Grains and potatoes are good sources of starch. Sugars include common table sugar, found in sweets and desserts, and the sugars in fruits and milk. Fats are present in eggs, meats, milk, nuts, certain vegetables, and other foods.

During digestion, carbohydrates are broken down into *simple sugars,* and fats are broken down into *fatty acids* and *glycerol.* The simple sugars, fatty acids, and glycerol are *oxidized* (burned slowly) in the body's cells. Oxidation releases the energy that we use in our daily activities and that enables the heart, lungs, and other organs to work. Oxidation also produces heat, which helps keep the body temperature at about 37° C. Without this

heat, the body would be unable to function properly.

Building and repairing tissues. Bones, muscles, and other body tissues constantly wear out and need to be repaired or replaced. In addition, growth depends on the formation of new tissues. The body uses the proteins in food to build and repair tissue.

All body tissues consist mainly of proteins. Proteins, in turn, are made up of chemical units called *amino acids.* The human body must obtain certain amino acids from the proteins in foods to make the proteins it needs. Digestion breaks down the proteins in foods into amino acids. The body then combines the amino acids into the kinds of proteins it requires. The protein value of foods depends on the amount and kinds of amino acids in them. Animal foods, such as meat, eggs, and dairy products, are especially rich in proteins. In addition, these proteins have all the amino acids the body needs. Grains, nuts, peanuts, and dried beans and peas are also high in protein. However, many plant foods lack one or more essential amino acids.

Some minerals help build body tissues. For example, calcium, phosphorus, and magnesium help build strong bones and teeth. Milk and other dairy products are good sources of these minerals.

Regulating body processes. The body uses proteins not only to build and repair tissues but also to help regulate various body processes. Certain proteins called *enzymes* speed up chemical reactions in the body. Enzymes help the body produce energy, digest food, and build other proteins. Many *hormones,* which regulate chemical activities throughout the body, are proteins. The *antibodies* that the body makes to fight infection are also proteins. All these proteins, like the proteins in body tissues, are made in the body from the amino acids in the food we eat.

The minerals and vitamins in food also play a major role in many body processes. People need only small amounts of minerals and vitamins. But these nutrients are just as important for good health as are carbohydrates, fats, and proteins. Unlike the other nutrients, however, minerals and vitamins can pass into a person's bloodstream without being broken down by digestion.

Minerals aid in numerous body processes. For example, iron and copper help build red blood cells. Sodium and other minerals regulate the amount of water in the body's cells. Calcium is necessary for blood clotting. Other minerals that are important to the human body include chlorine, cobalt, fluorine, iodine, magnesium, manganese, tin, and zinc.

Vitamins perform a variety of functions. They aid growth and help protect the body from disease. Vitamin A helps us see at night and promotes healthy bones, skin, and teeth. Various B vitamins help the body oxidize carbohydrates, fats, and proteins for energy. Vitamin C is necessary for healthy blood vessels and sound bones and teeth. Vitamin D helps the body use calcium and phosphorus.

Vitamins and minerals are found in a variety of foods. A well-balanced diet provides an adequate supply of all the vitamins and minerals a person needs. A shortage of certain vitamins can cause disease. For example, too little vitamin C causes scurvy, which is marked by sore gums and bleeding under the skin. Too little vitamin D can lead to rickets, a bone disease.

Why diets differ around the world

The kinds of food that people eat vary from one country to another and even within countries. In some countries, for example, the people eat a lot of meat. In some other countries, meat is served only on special occasions. People who are *vegetarians* eat no meat at all. Many people like certain foods that other people find very unappetizing. For example, the Chinese use the nests of birds called swifts to make bird's-nest soup. The birds build the nests of their saliva. The people of Spain enjoy fried baby eels. People in many countries consider frog's legs to be a treat.

People of various cultures also prepare foods differently. In many cases, the fuel resources and cooking equipment available determine how foods are prepared. Thus, some people cook foods over an open fire. Others may use a microwave oven. Still others may eat most of their foods raw. Some people add fiery spices to their dishes. Others prefer little seasoning. Some people eat only natural, or unprocessed, foods. Others eat foods that have been highly processed.

Diets differ for a number of reasons. These include (1) geographical reasons, (2) economic reasons, (3) religious reasons, and (4) customs. But differences in diet are not nearly as great as they once were. The growth of tourism and the development of modern transportation and communication systems have led to an exchange of foods and eating habits among people throughout the world.

Geographical reasons. The location, climate, and physical features of a region help determine what the people of that region eat. In general, people who live on islands or along seacoasts depend heavily on foods from the ocean. People who live far from the sea rely mainly on livestock or grains for food. People of tropical areas can grow a variety of fruits and vegetables the year around. People who live in cool regions, which have a short growing season, depend on such crops as grains or potatoes. Terrain and soil also help determine what crops the people of a region can grow. For example, maize grows best on level, open fields with rich, well-drained soil. Rice grows best in lowland areas where the soil holds water well.

Although geography still strongly influences what people in many parts of the world eat, its importance has declined—especially in industrialized countries. The development of faster transportation and of modern methods of food preservation enables many people to eat foods produced in distant countries. For example, people in numerous countries enjoy bananas from Ecuador, olives and oranges from Spain, dairy products from New Zealand, and sardines from Norway. In addition, many farmers have learned how to grow crops in unfavourable areas. Where land is hilly, for example, they might carve strips of land out of the hillsides. In dry areas, farmers might use irrigation. In areas with cold winters, they might grow certain fruits and vegetables in greenhouses during the winter.

Economic reasons. The variety and amount of food that people have to eat depend largely on their country's economy. But even in the richest countries, some people cannot afford a good diet, and others simply choose to eat foods that are not nourishing. On the other hand,

Where people live influences what foods they eat. Chinese workers harvest seaweed, *left.* It forms an important part of the diet in the Far East. Nomads of northern Africa gather and dry dates for food, *right.* The date palm grows easily in the hot, dry climate of the region.

some people in the poorest countries have a well-balanced diet.

Most industrialized countries can produce all the food their people need, or the countries can afford to import the extra supplies they need. The farmers use modern machinery and scientific methods to increase their production. Industrialized countries also have modern facilities to process, transport, and store food.

In highly industrialized countries, most families can afford to buy a variety of foods, and they are more likely to have a well-balanced diet. Their diet is rich in meat, eggs, and dairy products. They also eat large amounts of grain products and of fresh and preserved fruits and vegetables. They also enjoy the convenience of prepared or ready-to-cook foods. In addition, they often dine at restaurants or buy food from take-away restaurants to eat at home.

Most developing countries seldom produce enough food for all their people. In addition, the countries cannot afford to import the extra supplies they need. Many farmers are too poor to buy fertilizers, machinery, and other materials that would increase their output. Developing countries also lack modern facilities for processing, transporting, and storing food.

In some developing countries, many people suffer from an inadequate diet. They are too poor to buy all the food they need or a wide variety of foods. Millions of families depend on the foods they can produce themselves on small plots of land. Grains and other carbohydrates are the main foods of the majority of people in most developing countries. These foods are the least costly to produce or buy, and they require no refrigeration or other special storage. Meat, milk, and eggs are too expensive for most people. Many families bake their own bread and make most other foods from the basic ingredients. They might even grind grain into flour to make their bread.

Religious reasons. Many religions have rules that concern food. Some religions do not permit their members to eat certain foods. For example, the Hindu religion prohibits its members from eating beef because cattle are considered sacred. Some groups of Hindus are forbidden to eat any meat. Orthodox Jews do not eat pork, shellfish, and certain other foods. They also follow strict dietary laws regarding the storing, preparing, and serving of food.

Some religions set aside certain days for fasting and feasting. For example, Muslims may not eat or drink from dawn to sunset during Ramadan, the ninth month of the Islamic year. At the end of Ramadan, they celebrate with a feast.

Customs influence what people eat and how they prepare, serve, and eat foods. Many countries and regions have traditional dishes, most of which are based on locally produced foods. In many cases, the dishes of various cultures include the same basic ingredients. But different seasonings and cooking methods give the dish a special regional or national flavour. In the United States, for example, people enjoy such distinctively different chicken dishes as Southern-fried chicken, Louisiana chicken creole, and Texas-style barbecued chicken.

Many people consider France to be the world centre for high-quality foods and fine cooking. French chefs are especially known for their elaborate dishes with rich sauces and for their intricate cakes and pastries. Perhaps the most famous English dish is roast beef and *Yorkshire pudding,* a batter pudding baked in beef juices. Italy is known for its spaghetti, macaroni, and other *pastas* and for its sauces made with tomatoes, garlic, and olive oil. Sausages, potatoes, cabbage, and beer are common in the German diet. Scandinavians enjoy herring and other fish. They also are noted for their excellent cheeses and

many kinds of breads, which range from thin, crisp sheets to dark, heavy loaves.

The Spanish and Portuguese also eat a great deal of fish. Their use of onions and garlic for seasoning influenced cooking in the Caribbean islands, Mexico, and other parts of Latin America that were colonized by them. Caribbean cooking features such local fruits and vegetables as *plantains* (a kind of banana) and *cassava* (a starchy root). Mexican food is noted for its use of a variety of peppers. Mexicans enjoy flat breads, called *tortilla*, made from maize or wheat flour. They may eat the tortillas plain or wrapped around bits of cheese, meat, and beans to form *tacos*.

The main food of many people in the Middle East is *pitta bread*, a flat bread made from wheat. For celebrations, people of the region often prepare *shish kebab*. This dish consists of cubes of lamb, tomatoes, peppers, and onions roasted on a spikelike skewer. Rice is the main dish of many people in Japan, southern China, India, and Southeast Asia. Japanese meals commonly include vegetables, *tofu* (soybean curd), and raw or cooked fish. Chinese cookery, which many people consider among the finest in the world, differs greatly from region to region. Cooks in southern China stir-fry chopped vegetables and meat, which they serve with a mild sauce and rice. In northern regions, people enjoy spicy fried foods served with noodles. Indians and many Southeast Asians enjoy *curry*. This stewlike dish is made from eggs, fish, meat, or vegetables cooked in a spicy sauce.

Maize, rice, and other grains are the basic foods of many people in Africa. In Nigeria, food is often cooked in palm oil or peanut oil, and it may be sharply seasoned with red peppers. The people of Zaire serve maize and rice as a thick porridge. If they can afford it, they add meat or fish to the porridge. Many Ethiopians enjoy raw meat in a red pepper sauce.

In some cultures, the way food is served is almost as important as how it is prepared. For example, French and Japanese chefs carefully arrange food to make each dish look attractive. In Sweden, *smörgåsbord* is a popular way to serve guests. Smörgåsbord consists of a long table set with a dazzling selection of breads, cheeses, fish, salads, and hot and cold meats.

Customs can also affect the times when people eat. In most Western cultures, for example, people commonly eat three meals a day—breakfast, lunch, and dinner. Dinner, the main meal, is usually eaten in the evening. In rural areas, however, many families eat dinner about noon and have a light supper in the evening. Some British people add a light, extra meal called *tea* late in the afternoon. At this meal, they serve tea and such foods as biscuits, cakes, or sandwiches.

In most Western cultures, people eat from individual plates and use knives, forks, and spoons. In China and Japan, the people use chopsticks. In many societies, the people eat from a common serving dish and use few utensils. Some people scoop up their food with bread or with their fingers. For example, some Hawaiian islanders use their fingers to scoop up *poi*, a pastelike food made from the tropical taro plant.

The food industry

In developing countries, many families produce their own food or buy food from local farmers. In industrialized countries, however, most people depend on the food industry. This section describes the food industry in many industrialized countries.

The food industry consists of all the activities involved in producing food and getting it to consumers. The main branches of the industry are (1) production, (2) processing, (3) packaging, (4) transportation, and (5) marketing. Government regulations cover each branch and help assure consumers of safe, good-quality products. In addition, food companies and other organizations conduct research to increase the food supply and to im-

The human diet differs greatly in industrialized and developing countries. In industrialized countries, most people, such as the shopper on the left, can afford to buy a wide variety of foods. In developing countries, many families, such as the one in Nepal on the right, must produce their own food.

prove food products.

The food industry is one of the largest and most important industries in the world. It provides jobs for millions of people throughout the world.

Each branch of the food industry contributes to the prices of foods in the market place. The prices reflect the cost of producing the basic food as well as the processing, packaging, transportation, and marketing costs. All these costs plus the profits each branch of the industry tries to make are paid by consumers.

Production of food is the job of the farmer. Farmers grow crops and rear animals. In many places, farmers specialize in producing certain kinds of crops, such as fruits, grains, or vegetables. Other farmers may run dairy farms, pig farms, or sheep farms. Farmers may concentrate on producing only one kind of food. For example, a farmer may grow only sugar-cane, or only bananas. Another farmer may raise only poultry. Food production is becoming more and more efficient because an increasing number of the world's farmers are using machinery, fertilizers, weed-killers, and pesticides. These farmers can farm greater areas, and employ fewer workers.

The production of basic foods also includes the activities of commercial fishing fleets. These fleets catch huge quantities of fish and shellfish.

Processing. Most of the foods we eat have been processed. Processing changes basic foods in some way. Many processors simply add chemicals called *additives* to foods. The various kinds of additives are intended to improve some quality of a food, such as its colour, flavour, nutritional value, or storage life. However, many people consider additives to be dangerous to their health. Other processors use basic foods to manufacture entirely new food products.

Fresh eggs, fruits, and vegetables may be only washed and sorted before they reach the market. Or they may be dried or frozen. Fruits and vegetables also may be canned or pickled or used to make juice.

Meat processors slaughter cattle, pigs, and sheep. They then prepare the fresh meat for shipment to market. Meat processors also can, cure, freeze, and smoke meat, and they make it into sausages. Processors also slaughter and prepare chickens, turkeys, and other poultry for market.

Some large fishing vessels carry their own processing equipment. But most fishermen carry their catches into port for processing. Workers wash and clean part of the catch before sending it to market as fresh fish. Sometimes they make "fillets" of the fleshy sides by removing heads, tails, fins, and bones. Some of the catch goes to factories that clean and process fish into frozen, canned, salted, dried, and smoked products. Other sea foods, such as clams and oysters, must have their shells removed before processing.

Dairy plants pasteurize and homogenize milk. Some dairies also add vitamins to milk. In addition, dairies make butter, cheese, ice cream, and yoghurt from milk.

Processors manufacture many foods from basic plant and animal materials. For example, they make sugar from sugar beet and sugar cane, syrup from fruit, and cooking oil from peanuts, soybeans, and various other plants. Other manufactured foods include synthetic and convenience foods. Processors developed margarine – which generally is made from maize, cottonseed, safflower, or soybean oil—as imitation butter. They make egg substitutes from real egg whites and artificial yolks. Processors use cooked meats and vegetables in canned and dried soups, frozen dinners, and canned and frozen casseroles. They combine dried eggs, flour, sugar, and other foods in packaged dessert mixes.

Packaging makes foods easy to handle and identify. It also helps protect them from spilling and from being bruised or broken. In addition, special packaging materials and methods protect foods from air, bacteria, chemicals, insects, light, moisture, and odours—all of which might spoil the food. Attractive packaging also helps promote the sale of foods. The majority of foods, especially processed ones, are packaged. In most cases, machines pack the food into containers. Packaging is the

An attractive food display appeals to the eye and stimulates the appetite. This colourful assortment of dishes for an Easter celebration includes a cheese-covered ham, *centre*, and red caviar, *foreground*. For many people, the way that food is served is almost as important as how it is prepared.

High-quality milk is delivered by a tanker lorry to a creamery, where it is made into cheese. The milk is from nearby farms. Refrigeration keeps the milk fresh.

Wholesale produce firms, *above,* buy large quantities of fruits and vegetables from farmers. The firms then sell smaller amounts to restaurants, supermarkets, and other retailers.

last step in the processing of food.

Food companies use the kinds of packaging that best suit the needs and uses of their products. For example, eggs are packed in thick, sturdy cardboard or plastic cartons to protect them from breaking. Some foods, such as coffee, jam, and peanut butter, are used a little at a time. They are packed in cans or glass jars that have a resealable lid. Plastic bags and wrapping keep air away from meat, bread, potato crisps, and many other foods. Such dairy products as milk and cottage cheese are packed in lightweight paper cartons that are coated with wax or plastic to prevent leakage.

Packaging may also make the home preparation or use of food easier. For example, many frozen foods can be boiled in their plastic bags or baked in aluminium trays. Aerosol cans dispense whipped cream, and plastic squeeze bottles dispense sauces or mustard.

Transportation. Commercial shipping companies transport most of the food from producers to processors and from processors to market. Nearly all fresh foods are perishable, and must be shipped quickly. Many vegetable farmers transport their produce to nearby markets soon after it is harvested. Over longer distances, however, refrigerated trucks, railway goods wagons, and ships help keep perishable produce fresh. Refrigerated vehicles also transport dairy products and frozen foods. In some cases, aeroplanes transport highly perishable foods, such as fish, or expensive foods, such as live lobsters. Specially designed trucks and trains haul livestock.

Marketing. Some farmers sell eggs or fresh fruits and vegetables directly to consumers at roadside stands or through home deliveries. Many farmers take their produce to a *farmers' market* in a nearby city. There, food dealers and individual customers can purchase it.

Numerous grain, dairy, and other farmers sell their products directly to a food processor. Many other farmers belong to a *marketing cooperative.* A marketing cooperative collects the products of member farmers. It then sells the products to the processors that offer the highest prices. Farmers sell their livestock to meat processors at *auction markets.*

Most food processors and a number of farmers sell their products to a *wholesaler.* Wholesalers buy large quantities of a product and then sell smaller amounts to *retailers.* Food retailers include supermarkets, grocery shops, delicatessens, butcher shops, restaurants, and other businesses that sell food to consumers.

Supermarkets and groceries sell a variety of foods. Other shops sell only one line of food, such as baked goods, fish, or meat. Consumers can buy prepared meals at restaurants and cafeterias. In many office and public buildings, vending machines dispense foods.

Government regulations. The governments of many countries supervise the quality, cleanliness, and purity of foods. Laws protect the public's health, and prevent food companies from making false claims about their products.

These governments also set standards for grading and labelling foods such as fresh fruits and vegetables, meat, eggs, butter, cheese, and canned goods. They require that labels carry accurate information about the quality and weight of food and any substances added to it. They prohibit the use of additives such as food preservatives, seasonings, flavourings, and artificial colourings that may be harmful when eaten. Governments also have laws concerning weights, measures, and container volumes that protect buyers from fraud.

Government health departments set standards for milk, including minimum fat content and requirements

for pasteurization and handling. In an increasing number of countries, the date by which products should be consumed must be shown. Health departments also inspect sanitary conditions in restaurants and other places that serve meals.

Food research is conducted by food companies, food growers' associations, food institutes, government agencies, research foundations, and universities. Their efforts have led to a tremendous increase in the quantity, quality, and variety of foods available.

Agricultural researchers work to increase the food supply by developing more productive varieties of plants and livestock and more effective fertilizers and pesticides. Other researchers seek ways to improve the flavour, appearance, or nutritional value of food products. Still others study the effects of preservatives and packaging on the storage life of food.

Many food company researchers work to develop new foods, and they seek ways to make the home preparation of processed foods easier. Home economists develop new recipes, and dietitians and nutritionists look for ways in which to improve the human diet. Agricultural economists study farm management and crop and livestock production.

Food through the ages

Prehistoric times. The earliest people ate whatever plant food they could find, including wild fruits, mushrooms, nuts, roots, and seeds. They also caught fish and small land animals and ate the meat of dead animals that they found. In time, people developed weapons to hunt large animals, such as bears, bison, deer, and wild cattle. Early people probably spent much of their time searching for food. If the food supply in an area ran out, the people moved on.

The earliest people probably roasted some of their food over burning wood from fires that had started naturally. After people discovered how to make fire, they could roast food more often. After they learned how to make pots, they could also boil and stew food.

By about 8000 B.C., people had begun to raise plants and animals for food. Farming assured people of a steadier food supply. It also meant settling in one area instead of travelling about in search of food. Grains were especially important crops to early farmers. Farmers also raised cattle, goats, sheep, and other animals for meat and milk.

Some groups of prehistoric people were nomadic shepherds. These groups travelled across the countryside in well-established patterns. They raised such animals as camels, goats, and sheep. A large part of the nomads' diet consisted of meat and milk from their livestock.

Ancient times. Between 3500 and 1500 B.C., the first great civilizations developed in river valleys. These valleys were the Nile Valley in Egypt, the Tigris-Euphrates Valley in what is now Iraq, the Indus Valley in what is now Pakistan, and the Huang He Valley in China. All these valleys had fertile soil and a favourable climate, enabling farmers to produce abundant yields. In ancient Egypt, for example, farmers along the Nile could raise two or three crops a year on the same fields. They grew barley and wheat and such vegetables as beans, lettuce, and peas. They also raised such fruits as grapes and melons. Their livestock included cattle, goats, and sheep.

Ancient Greece and later ancient Rome could not produce enough food for their growing populations. They thus had to import large quantities of food from other countries. They also conquered and colonized lands that had plentiful food supplies. The Greeks and Romans thus enjoyed cherries from Persia (now Iran); apricots, peaches, and spices from the Orient; and, most importantly, wheat from Egypt. By the A.D. 200's, the Roman Empire covered a large part of Europe, most of the Middle East, and the Mediterranean coast of Africa. Most of the empire's large farms specialized in raising wheat, which formed the basis of the Roman diet.

The Middle Ages. After the Roman Empire fell in the A.D. 400's, international trade dropped sharply. In Europe, most of the land was divided into *manors.* A manor was a large estate controlled by a lord and worked by peasants. Manors provided all the foods needed by the lords and the peasants. These foods included grains; grapes and other fruits; such vegetables as beans, cabbages, and turnips; and poultry, cattle, and other livestock.

Between 1000 and 1300, thousands of Europeans went to the Middle East to fight in the Crusades. The crusaders acquired a taste for spices and Middle Eastern foods. After they returned to Europe, their desire for different foods helped renew international trade. It also helped stimulate the exploration of new lands.

Illustration from the *Hours of the Virgin* (1500's), an illuminated manuscript by an unknown Flemish artist

During the Middle Ages, food was produced on *manors,* large estates controlled by lords. The peasants who lived on a manor raised livestock and grew crops.

Foods of the New World. In 1492, the Italian explorer and navigator Christopher Columbus sailed west from Spain. He landed in America and his voyage led to a new world of food for Europeans. American Indians introduced Europeans to avocados, chocolate, maize, peanuts, peppers, pineapples, sweet and white potatoes, squashes (gourds), and tomatoes.

The American colonists enjoyed many of the Indian foods. In fact, the Indians taught them how to grow maize, which became the most important crop of the early colonial period.

Recent developments. In most industrialized countries today, people's food habits are changing. The growth of tourism and of immigrant communities in some countries have been responsible for some foods becoming familiar in countries where they were previously almost unknown. Chinese cuisine has become internationally popular, and Indian and other Asian-style restaurants are now to be found in many countries.

At the same time, snacks have become part of the daily diet of some Westerners, while others worry about becoming overweight and watch what and how much they eat. Many health-conscious people believe that food additives and other chemicals used in producing and processing foods harm the body. They are also concerned that many important nutrients are lost during processing. These worries have led to the popularity of so-called *health foods.* Health foods include many unprocessed foods as well as foods grown without the use of chemical fertilizers and pesticides.

Many health-conscious people also try to include more fibre in their diet. Fibre is thought to help prevent certain intestinal diseases. Fresh fruits and vegetables and whole-grain foods supply dietary fibre. Some people avoid butter, eggs, fatty meats, and other foods high in a fatty substance called *cholesterol.* Too much cholesterol in the bloodstream may contribute to hardening of the arteries.

Another trend is the rising popularity of cooking as a hobby. In contrast, more people eat many of their meals in restaurants. Fast-food restaurants, especially, have become increasingly popular.

Related articles. See various country articles in ***World Book,*** in which local foods are discussed. See also:

Kinds of food

Bread, Cereal, Cheese, Egg, Fruit, Grain, Meat, Milk, Nut, Poultry, Spice, Sugar, Sweets, Vegetable

Nutrition

Carbohydrate, Diet, Dietitian, Digestive system, Fat, Health, Lipid, Nutrition, Protein, Vitamin, Weight control

Preparation and processing

Cold storage, Cooking, Dehydrated food, Fishing industry, Food, Frozen, Food additive, Food preservation, Freeze-drying, Meat processing, Packaging, Refrigeration

Special food dishes

Barbecue, Bird's-nest soup, Caviar, Pemmican, Trepang

Beverages

Alcoholic beverage, Chocolate, Coffee, Maguey, Maté, Soft drink, Tea

Other related articles

Agriculture, Christmas (Christmas feasting), Climate (Food and climate), Easter (The lamb; Other foods), Eskimo (Food), Fast, Flower (Other uses), Food and Agriculture Organization, Food poisoning, Food supply, Kosher, Marketing, Plant, Prehistoric people (Food), Restaurant, Salt, Supermarket, Thanksgiving Day

Outline

I. **Sources of food**
- A. Food from plants
- B. Food from animals

II. **How the body uses food**
- A. Producing energy
- B. Building and repairing tissues
- C. Regulating body processes

III. **Why diets differ around the world**
- A. Geographical reasons
- B. Economic reasons
- C. Religious reasons
- D. Customs

IV. **The food industry**
- A. Production
- B. Processing
- C. Packaging
- D. Transportation
- E. Marketing
- F. Government regulations
- G. Food research

V. **Food through the ages**

Questions

How does the physical environment help determine what the people of a region eat?
What are the most important foods from plants? From animals?
What are *food additives*? What do they do?
How does packaging help keep food from spoiling?
What is *curry*? *Shish kebab*? *Smörgåsbord*?
Why is it important to have a well-balanced diet?
What are some reasons diets differ in industrialized and developing countries?
What are *health foods*? Why are they popular?

Food, Frozen. Freezing is one of the best ways to preserve foods. Food-processing companies freeze such foods as baked goods, orange juice, meat, pizzas, vegetables, and complete precooked meals. Many people freeze foods at home. Freezing preserves food by preventing the growth of microbes that spoil food and by slowing down food-spoiling chemical reactions. All frozen foods should be stored at temperatures of $-18°$ C or below.

Quick-freezing preserves most foods better than slow-freezing does. Slow-freezing changes the structure of the cells of some foods in such a way that the foods leak fluids when they are later defrosted. This leakage results in undesirable changes in the food's texture. For example, leakage can make vegetables mushy, and make meat tough. Also, the food may not cool quickly enough to prevent spoilage by microbes or by chemical reactions. Food frozen at home is slow-frozen.

Almost all foods frozen commercially are quick-frozen. Quick-freezing causes little change in the structure of food cells and prevents spoilage by microbes and by chemical reactions.

Commercial freezing of food began in the United States before 1865. Food-processing companies originally froze food by using ice cut from ponds. In the late 1850's, such companies began making ice by using a process that involved the mechanical compression of ammonia (see **Refrigeration** [Mechanical refrigeration]).

The ice was used to freeze meat and vegetables for international distribution. These early methods of freezing allowed only for slow-freezing. But in 1925, Clarence Birdseye, an inventor from Massachusetts, U.S.A., developed a quick-freezing process for fish and vegetables. In 1929, the Postum Company (now General Foods Corporation) purchased his patents and began to produce frozen foods. Frozen foods became popular in the 1950's, when freezers became widely available.

Commercial methods of quick-freezing

There are several commercial methods of quick-freezing. These include (1) air-blast freezing, (2) indirect-contact freezing, (3) nitrogen freezing, (4) dry-ice freezing, and (5) liquid-chlorofluorocarbon (CFC) freezing.

Air-blast freezing uses a steady flow of cold air at −40° to −50° C. The cold air is produced by passing air over coils that are cooled by a mechanical ammonia-compression system. The cold air is blown into an insulated tunnel, and the food passes through the tunnel on a conveyor belt. In most cases, processing firms package the food before sending it through the tunnel. For faster freezing, some processors freeze such foods as vegetables and fruit before packaging them.

Indirect-contact freezing can be done in several ways. One method uses adjustable metal plates that have hollow walls. A *refrigerant* (cooling substance) inside the plate walls cools the plate surfaces to about −33° C. Packaged foods are placed between the plates, which are then adjusted to make contact with the upper and lower surfaces of the packages. As the plates absorb heat, the food freezes solid. Another indirect-contact system uses a refrigerated solution of salt or of a type of alcohol called *glycol*. A mechanical conveyor moves food in cans or other packages through the solution. Processing companies use salt solutions and glycol solutions to freeze such products as canned fruit juices and poultry that is sealed in plastic film.

Nitrogen freezing. In this process, liquid nitrogen under pressure at −173° C is first *vaporized* (turned into a misty gas). The cold nitrogen vapour then flows into a chamber, where it freezes the food. This method is expensive, but it freezes food faster and better than the air-blast and indirect-contact methods do.

Dry-ice freezing resembles nitrogen freezing, except that it starts with powdered *dry ice* (solid carbon dioxide) instead of with liquid nitrogen. The dry ice vaporizes, and the cold vapour freezes the food. The dry-ice method costs even more than the nitrogen method.

Liquid-CFC freezing. In this method, unpackaged food is sprayed with, or dipped in, liquid chlorofluorocarbons (CFC's) at −29° C. CFC's are chemicals that contain carbon, chlorine, and fluorine. Because CFC's harm the environment, many countries have signed a treaty that bans the production of CFC's after 1996. As a result, food-processing companies have begun to use other methods in place of liquid-CFC freezing. Processing companies use the liquid-CFC method to freeze such foods as shrimp and corn on the cob.

Freezing food at home

People freeze foods at home by placing them in freezers or in the freezer compartments of refrigerators. Both of these kinds of freezers operate at about −18° C.

Concentrated orange juice is frozen in cans. First, the juice is poured into the cans *(above)*. Then the cans are sealed and immersed in a refrigerated alcohol or salt solution.

Freezer capacities vary considerably. A 0.3-cubic-metre freezer can hold up to about 12 kilograms of food. Some large cabinet units hold as much as 70 kilograms. But regardless of a freezer's size, it is important not to overload the unit. Overloading prevents the freezer from maintaining the temperature at or below −18° C. A freezer should not be completely filled with unfrozen food, because the food will freeze too slowly.

Home freezers freeze food more slowly than do industrial-freezing systems. As a result, freezing food at home results in lower food quality than does industrial freezing. However, many foods make acceptable products when frozen at home. Such foods can be stored for a year at −18° C if properly prepared, packaged, and frozen. Exceptions include avocados, cabbage, celery, cooked egg whites, custards, fatty fish, grapes, pears, vegetable salads, and tomatoes.

Preparing foods for freezing involves several steps. First, the foods should be washed, trimmed, and cut to the desired size. Vegetables and some fruit should then be *blanched*—that is, steamed or boiled for one to three minutes. Blanching destroys enzymes in the food. The enzymes speed up chemical changes that can give the food a disagreeable odour or flavour or a different colour. Enzymes can operate even in a freezer.

Fruit may or may not be blanched, depending on its intended use. Fruit intended for cooking should be blanched. But blanching gives food a cooked flavour, and so fruit that is to be eaten uncooked should not be blanched. Fruit that is not blanched loses quality more rapidly in a freezer than does blanched fruit.

Meat needs little preparation for freezing except trimming of waste parts. In general, meat, including poultry and fish, should be frozen uncooked. Cooked meat, when frozen, spoils two or three times faster than meat frozen raw. Freezing meat in a sauce slows down the spoiling. Poultry, before being frozen, must be cleaned, dressed, and thoroughly washed inside and out. Fish typically are cleaned, cut into fillets, and skinned—or cleaned, scaled, and cut into steaks.

In general, thawed foods should not be refrozen. Refreezing food and thawing it again reduces the food's quality. In addition, refreezing the food may make it unhealthy, unless it previously was thawed in a refrigerator or in a microwave oven.

Packaging is an important part of freezing food at home. Proper packaging protects the food while it is stored in the freezer. The food should be packed tightly in an airtight container to prevent evaporation. Evaporation can dry the food out. It also can cause snow called *package ice* to form inside containers that have too much air space. In addition, evaporation results in a dull or dried out appearance called *freezer burn*. Food should be placed in small packages to speed freezing.

Problems with frozen foods

Frozen foods can cause food poisoning if they are not frozen soon enough or if they are not cooked soon enough after thawing. Food poisoning organisms can grow in food if its temperature exceeds 7° to 10° C, even if for only a few hours. If the food is cooked before it is frozen, it should immediately be put in a refrigerator or freezer. Allowing warm food to cool at room temperature permits the growth of food poisoning microbes that may survive the freezing process.

Foods should be thawed in a microwave oven or, if such an oven is not available, in a refrigerator. Both methods prevent the growth of food poisoning organisms. However, refrigerator thawing allows physical and chemical changes that reduce food quality.

To help prevent the loss of quality that occurs in vegetables as a result of slow thawing, processing firms package many kinds of vegetables in sealed plastic pouches. Consumers can thaw the vegetables rapidly – and cook them – by transferring the unopened pouch from a freezer directly into boiling water. The tightly packed pouches also prevent freezer burn and the formation of package ice. Many frozen foods can be cooked in a microwave oven as soon as they are removed from the freezer.

Many countries require that frozen foods be stored at or below −18° C. However, supermarket freezer shelves are often overstocked, and many freezers have automatic defrost cycles that raise and lower the food's temperature repeatedly. The temperature of commercially frozen food also may rise and fall as the food is moved from one freezer to another during distribution. As a result, some frozen foods often exceed −18° C. The repeated temperature changes lead to loss of food quality. For example, they cause ice crystals to form in ice cream, giving it a grainy texture. They also promote freezer burn and the formation of package ice.

See also **Birdseye, Clarence; Food preservation; Refrigeration.**

Food additive is any chemical that food manufacturers intentionally add to one of their products. Some additives increase a food's nutritional value. Others improve the colour, flavour, or texture of foods. Still others keep foods from spoiling. Common food additives include iodine, put into salt to prevent goitre, and baking powder, added to dough to make it rise.

Some food additives come from other foods. Scientists also create many synthetic additives in the laboratory. Some people consider food additives dangerous to their health. But many of these chemicals occur naturally in foods that people have eaten for centuries.

Kinds of additives. Food manufacturers use hundreds of additives in processing various foods. These additives can be classified into six major groups: (1) preservatives; (2) nutritional supplements; (3) flavouring agents; (4) colouring agents; (5) emulsifiers, stabilizers, and thickeners; and (6) acids and alkalis.

Preservatives, such as salt, prevent the growth of bacteria that cause foods to spoil. Preservatives called *antioxidants* keep fats and oils from spoiling and prevent other foods from becoming discoloured.

Nutritional supplements, such as iron, minerals, and vitamins, make foods more nourishing. A number of such supplements, including vitamin B_1 and vitamin B_2, are added to flour. These additives enrich flour and thus improve the nutritional value of bread and other products made from it. Milk with vitamin D added helps prevent rickets, a bone disease.

Flavouring agents include all spices and natural fruit flavours, as well as such artificial flavours as the vanillin used in ice cream. Some flavouring agents, such as monosodium glutamate (MSG), add no flavour of their own but improve a food's natural flavour.

Colouring agents make synthetic foods resemble real ones. Margarine manufacturers add yellow colouring to make their product look like butter. Manufacturers also add colouring to many canned foods to replace natural food colours lost in processing. Some colouring agents, such as the orange colour added to the skins of oranges, improve the appearance of a food.

Emulsifiers, stabilizers, and thickeners help the ingredients in a food to mix and hold together. Algin, an emulsifier, gives ice cream its creamy texture and maintains the mixture of liquids in salad dressings. Carrageenin, the most widely used stabilizer, keeps the chocolate particles in chocolate milk from settling. Pectin and gelatin are used to thicken jams and jellies.

Acids and alkalis help maintain a chemical balance in some foods. Alkalis neutralize the high acid content of such canned foods as peas and olives. Some acids add flavour. Citric acid added to fruit juice gives it a tart taste. Carbonic acid puts the fizz in soft drinks.

Government regulations. Government committees of experts and regulatory bodies define the maximum amounts of additives that are permitted in food. Legislation defines the principles involved in the use of food additives. Regulations vary throughout the world, though lists are available specifying those foods that may contain certain additives. Maximum permitted concentrations of additives are also given. The European Community has developed a list of commonly used additives that are generally recognized as safe within Community countries and other parts of the world. The safety evaluation of food is generally based on studies performed on animals. These studies have led to the development of acceptable daily intakes (ADI) for each additive. The most widely used ADI values have been established by the Joint Expert Committee on Food Additives (JECFA) of the Food and Agriculture Organization and the World Health Organization.

See also **Monosodium glutamate.**

Food and Agriculture Organization (FAO) is a specialized agency of the United Nations. Its full name is the Food and Agriculture Organization of the United Nations. The agency works to improve the production, distribution, and use of food and other products of the world's farms, forests, and fisheries. Its goals include raising the level of nutrition and the standard of living of

of people, especially the rural poor. About 160 countries belong to the FAO.

The FAO works in four ways. (1) It provides technical advice and assistance on behalf of governments and development funding agencies. (2) It collects, analyses, and distributes information. (3) It advises governments on agricultural policy and planning. (4) It acts as a neutral forum where governments can discuss food and agricultural issues. The FAO and the United Nations co-sponsor the World Food Programme. This programme uses food surpluses and cash from donor countries to provide emergency relief and to stimulate development. The FAO was set up in 1945. It has headquarters in Rome.

See also **Food supply** (Food supply programmes); **United Nations** (Fighting hunger).

Food chain. See **Ecology**; **Fish** (Fish in the balance of nature); **Sun** (Heat and light for life); **Environmental pollution** (Other kinds of pollution).

Food colouring. See **Food additive** (Kinds of additives).

Food poisoning results from eating food that has been contaminated by bacteria or chemicals or that is poisonous in itself. The symptoms vary widely, but in most cases they include nausea, vomiting, cramps, and diarrhoea. In some types of food poisoning, muscle paralysis and even death may occur.

Most food poisoning results from bacterial contamination. Bacteria can invade almost any food, but contamination occurs most frequently in meats, seafoods, some preserved foods, and dairy products, especially creams and custards. Bacterial contamination can be prevented by using hygienic methods in preparing and storing foods.

Contamination by *staphylococcal bacteria* causes most food poisoning (see **Staphylococcus**). These bacteria release *toxins* (poisons) into the contaminated food. The toxins produce the illness. Another common type of food poisoning results from contamination by *Salmonella* bacteria. These organisms cause illness after reproducing in the digestive tract (see **Salmonellosis**). Staphylococcal and salmonella food poisoning affect the stomach and intestines, but most victims recover quickly. *Botulism* is a far more serious, often fatal, type of bacterial food poisoning. It is caused by toxins that form in improperly canned foods and is characterized by muscle paralysis (see **Botulism**).

Foods contaminated by such chemicals as lead, arsenic, and mercury cause serious forms of food poisoning. Contamination by pesticides and other organic chemicals may also lead to food poisoning.

Certain varieties of mushrooms and some kinds of fish are the best-known examples of foods that are poisonous in themselves. Eating such foods can lead to serious or even fatal poisoning.

See also **Food preservation**; **Environmental pollution** (Other kinds of pollution); **Mushroom** (Poisonous mushrooms); **Mycotoxin.**

Food preservation is the term used to describe any process used to slow the normal decay of food. There are many forms of food preservation. They range from simple refrigeration to treatment with radiation. Some methods date back to prehistoric times. But others have been developed only as a result of modern advances.

Food preservation helped make today's civilization possible. Without it, most people would have to grow their own food. Food could not be transported from rural areas to urban areas without being spoiled or destroyed by pests. As a result, large cities could not exist. In addition, famines would probably be more frequent and widespread, because supplies of food could not be stored to guard against emergencies.

How food spoils

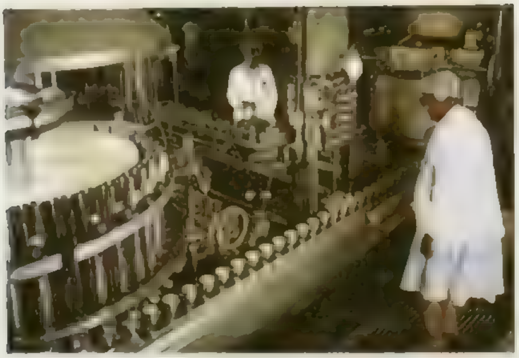
All foods will eventually spoil if not preserved. Some, such as nuts or grains, can be stored for months with very little treatment. Others, such as milk or meat, stay fresh for only one or two days without preservation.

Food spoilage results from two chief sources: pests and *microorganisms*. Pests include insects and rodents. Many pests destroy or severely damage crops simply by feeding on them. Some pests transmit serious diseases to foods. Pests are controlled by pesticides or by storing food in such containers as tightly sealed steel bins that prevent rodents from getting at food.

Microorganisms include bacteria, moulds, and yeasts. Food spoils when enough microorganisms multiply in the food to cause changes in flavour or odour. Bacteria multiply very rapidly to produce acids, gases, and other chemicals—some of which may be poisonous to human beings. Moulds are fungi that grow best on moist food surfaces at temperatures of about [illegible]° C. However, moulds continue to reproduce at much cooler temperatures because the spores are strong and hard to kill. Mould growth is easy to see and makes food look unappetizing. Yeasts produce alcohols and certain organic compounds called esters. In some foods, alcohols and esters produce disagreeable flavours.

Food spoilage may occur before flavour or odour change is detectable. For example, bacteria known as *Clostridium botulinum* may not be readily noticeable in foods. However, these bacteria may cause an extremely dangerous kind of food poisoning called *botulism*. Botulism is often fatal to human beings (see **Botulism**).

Food preservation helps prevent food spoilage. Canning, freezing, and a number of other methods are used to preserve a wide variety of foods, such as those shown above.



Canning preserves food by heating it in airtight containers. Before any food is canned, inspectors make sure the food is properly cleaned and prepared, *above*.

How foods are preserved

The chief methods of food preservation include (1) curing, (2) canning, (3) cold storage, (4) freezing, (5) drying, (6) adding additives, (7) irradiation, and (8) aseptic packaging. In addition, other methods, such as pasteurization, fermentation, fumigation, and controlled atmosphere storage, help preserve some foods.

Curing involves the addition of such ingredients as salt, spices, sugar, sodium nitrate, and sodium nitrite to food. It is one of the oldest methods of food preservation. Today, curing is widely used in the production of ham, pork, corned beef, and some other meats. It is also sometimes used to preserve fish, potatoes, cucumbers, and certain nuts.

Each of the ingredients that are used for curing acts on food in its own way. Salt slows the growth of microorganisms and removes part of the water from the food. Sugar counters the hardening effect of the salt. Sodium nitrate and sodium nitrite help meat keep its red colour. Spices are added primarily for flavour.

Curing ingredients are applied to food in several ways. In some cases, they are rubbed onto the food. They are also applied by soaking the food in a solution of the ingredients, injecting the solution directly into the food, or mixing the ingredients with the food.

Some meat and fish are cured by smoking. Wood smoke contains chemicals that slow the growth of microorganisms. Meat to be smoked, such as ham, bacon, and other salt-cured products, is hung in a *smokehouse.* A slow-burning fire provides the smoke.

Some studies have shown that certain curing agents may be harmful. For example, too much salt in a diet may cause high blood pressure. Under certain conditions, sodium nitrite may combine with other chemicals to form nitrosamines, which can cause cancer.

Canning is the most common method of food preservation in industrialized countries. In this process, foods that have been sealed in airtight containers called cans, tins or jars, are heated to destroy microorganisms that may cause spoilage. Canning plants produce a wide variety of canned foods, including fruit, vegetables, fish, meat, poultry, and soups.

Before any food is canned, it is thoroughly cleaned. Many foods, such as fruits and vegetables, are cut, sliced, or peeled before canning. After the raw food is prepared, the canning process follows five basic steps: (1) filling, (2) exhausting, (3) sealing, (4) processing, and (5) cooling.

Filling. Machines fill cans at speeds up to 1,200 containers a minute. But some filling may be done by hand. Raw foods are filled into metal or glass containers. The amount of empty space in the can, called *headspace,* is carefully controlled. Too little headspace causes cans to bulge during heating. Too much headspace results in underweight cans and shorter storage life.

Exhausting involves the removal of part of the air in the headspace to form a partial vacuum in the can. Exhausting reduces the bacterial growth in the can because most bacteria cannot survive without oxygen. This process also prevents bulging of the can during heating.

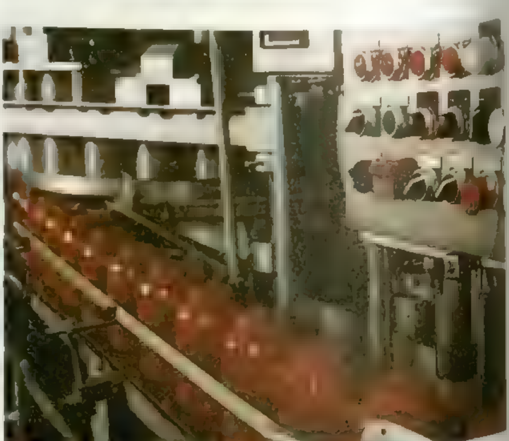
Sealing. Machines seal several hundred cans per minute. Glass containers are sealed at a somewhat slower rate. Sealed containers are airtight.

Processing. In this step, containers are heated to a carefully controlled temperature for a measured length of time. The degree of heat and length of exposure vary with the product being canned and the size of the container. During processing, microorganisms that may cause spoilage are destroyed. Containers are heated in cookers called *retorts.*

Cooling follows the processing step to prevent overcooking. Containers may be cooled by transferring them from the retort into cold water, by spraying them with cold water, or by partially cooling them in water and then air-cooling.

One of the disadvantages of canning is that the heat required for sterilization changes the food's texture, colour, and flavour. In addition, some nutrients are lost in the canning process. However, canned foods are popular with consumers because of their low cost, convenience, variety, and relatively long storage life.

Cold storage, or *refrigeration,* keeps food fresh at temperatures above 0° C. Storage at or near that temperature stops the growth and activity of most microorganisms that cause food spoilage. It also decreases enzymes that cause changes in the colour, flavour, and texture



Filling is generally done by machines. Some machines fill up to 1,200 containers a minute. The glass containers shown above are being filled with spaghetti sauce before they are sealed.

of foods. Foods requiring refrigeration include fish, meat, eggs, milk, fruit, and vegetables.

Cold storage has an advantage over most other forms of preservation, because it produces few changes in the food. Original colour, flavour, and nutrients of food are retained with refrigeration.

Freezing removes heat from food through the use of low temperatures. Freezing slows the growth of microorganisms and stops the breakdown of nutrients. Because most foods contain large amounts of water, they freeze solidly at 0° to −4° C.

Vegetables are among the main foods preserved by freezing. Before they are frozen, vegetables are first *blanched* (scalded). Blanching prevents enzymes, which are not killed during freezing, from changing the flavour of vegetables. Other foods preserved by freezing include meat, fish, poultry, and juices. Before freezing, food may be cleaned, peeled, or prepared in other ways. Some foods, such as those used for frozen oven-ready meals, are cooked before freezing.

The most common commercial freezing devices used today include (1) *plate freezers,* (2) *continuous-conveyor freezers,* (3) *air-blast freezers,* and (4) *cryogenic freezers.* Plate freezers are cabinets with shelves that have refrigeration coils beneath them. Packages of food are placed on these shelves, and the cabinet is closed for several hours until the food freezes. Continuous-conveyor freezers are large rooms with temperatures ranging from −23° to −34° C. Packages of food travel slowly back and forth in the room on conveyor belts until they freeze.

Air-blast freezers are similar to continuous-conveyor freezers. But air-blast freezers use a fan in the room to create a high wind. This wind, combined with temperatures as low as −34° C, causes quick freezing of foods. Cryogenic freezers spray liquid nitrogen or liquid carbon dioxide directly onto food to freeze it very rapidly. For example, an apple pie that takes three hours to freeze in an air-blast freezer takes only five minutes in a cryogenic freezer.

Freezing preserves nutrients better than any other preservation method. In addition, frozen vegetables contain little—if any—salt.

Drying uses heat to remove moisture from food. The microorganisms that cause food spoilage require moisture to survive. Once food dries to the point where most of its water is gone, microorganisms cannot grow. Raisins, peas, soups, milk, eggs, mushrooms, and many other foods are dried. A great variety of drying techniques are used for these products, including (1) *sun drying,* (2) *tray drying,* (3) *tunnel drying,* (4) *spray drying,* (5) *pulse-combustion drying,* and (6) *drum drying.*

Sun drying consists of spreading foods in thin layers under the sun. Fruits and grains are often dried in this manner. Tray drying uses the circulation of hot air through large insulated cabinets to dry food. Tunnel drying is similar to tray drying, but the cabinet is longer. Food moves continuously through the tunnel dryer on a cart or conveyor belt.

Spray drying involves spraying liquids or *slurries* (mixtures of liquids and finely ground solid particles) into a large, heated chamber. Hot air is also blown into the chamber. The hot air dries the food droplets to form powders. Dried milk is one of the products obtained by this method. Pulse-combustion drying combines heat and powerful sound waves to dry food that cannot be dried by other methods. High-fructose corn syrup is one product dried in this manner. In drum drying, a thin film of food is spread onto a heated rotating cylinder called a drum. Food dries on the drum and is scraped off before the drum makes a complete rotation.

Freeze-drying. Under certain conditions, ice can change directly from a solid into a vapour without first becoming a liquid. This process, called *sublimation,* serves as the basis for the freeze-drying of food. In commercial freeze-drying, water is removed from food while the food is still frozen. Frozen food is first placed on shelves in a large vacuum chamber. The shelves are then heated to keep the food just below the melting point. As the ice vaporizes, the food maintains its shape, but becomes a spongelike, lightweight dry solid.

Freeze-drying, unlike drying, does not cause shrinkage of the food product as the water is removed. Drying produces hard, solid foods that often do not return to their original texture when *rehydrated* (have water restored). Freeze-dried foods not only retain their original flavour and texture better than dried foods, but they retain nutrients better as well. However, freeze-drying is an expensive process, so it is used for only a few foods. They include instant coffee, dried soup mixes, strawberries, mushrooms, and shrimps.

Adding additives to foods prevents spoilage or increases nutrients. Additives are chemicals used when other methods of food preservation are unsuitable or inadequate. In most countries, additives require approval by a government department. Some additives help keep foods in an edible condition for as long as possible. These additives include *antioxidants* and *preservatives.* Others, such as *sequestrants* and *humectants,* help foods keep an appetizing appearance.

Many foods contain unsaturated fats, fatty acids, or oil-based vitamins. When these compounds combine with oxygen, they change into new compounds. Often this change results in the formation of harmful flavours and odours or the loss of nutrients. Antioxidants prevent the original compounds from combining with oxygen. The use of such antioxidants as butylated hydroxyanisol (BHA), propyl gallate, and ascorbic acid (vitamin C), has met with general acceptance.

Preservatives stop microorganism growth in those foods that cannot be processed by such means as canning or freezing. Preservatives are used extensively in bread and other baked goods, pickled vegetables, fruit juices, and cheese. Common preservatives include benzoic acid, sorbic acid, and sulphur dioxide.

Some foods contain tiny amounts of metals, such as iron or copper. These metals cause oxygen to combine with foods and produce changes in colour. Sequestrants stop these metals from reacting with food. Common sequestrants include ethylenediamine tetra-acetate (EDTA) and citric acid. Humectants help retain moisture in such products as breads and cakes. These foods become unattractive and less appetizing as they dry out. Examples of humectants are glycerol and sorbitol.

Aseptic packaging sterilizes the food product and then packages it in a sterilized container. The food will keep indefinitely without refrigeration if this process is done correctly. For example, aseptic packaged milk can be stored for months in a kitchen cupboard.

Typical aseptic containers include foil-lined cartons, plastic cups, and plastic bags. These containers cost and weigh less than the metal cans or glass bottles traditionally used in packaging. Another advantage of aseptic packaging is better flavour. Cans or bottles require much longer heating time for sterilization. The longer foods are heated, the more the flavour changes. In the aseptic process, foods can be heated rapidly outside the container. Therefore, aseptically packaged foods have a more natural flavour as well as more nutrients.

Since the United States first approved aseptic packaging of foods in 1981, the process has gained popularity. This is because it is cheaper and more convenient than other preservation methods.

Irradiation treats food with *ionizing radiation*—that is, radiation that produces electrically charged particles. X rays, gamma rays, and electron beams are all forms of radiation used to preserve foods. Low doses of radiation kill bacteria and inactivate enzymes with little or no chemical change in foods. Irradiation also kills insects in foods and stops the sprouting of some vegetables. In addition, it eliminates such poisonous microorganisms as salmonella or trichinae, which may cause illness.

Food irradiation was accepted by the United Nations World Health Organization in 1961. It is used by Belgium (food ingredients and spices), Canada (seafood and pork), Hungary (onions and paprika), the Netherlands (frozen fish and seafood), South Africa (fruit and vegetables), Ukraine and Russia (cereals), and the United States (potatoes, flour, and spices). But there is continuing controversy over its possible harmful effects.

Other methods of food preservation include (1) *pasteurization,* (2) *fermentation,* (3) *fumigation,* and (4) *controlled atmosphere storage.* Pasteurization is a rapid heat treatment that destroys harmful bacteria but causes little nutrient damage. Milk is pasteurized, as are some wines and other liquids. Fermentation chemically changes foods to help preserve them. Fermentation produces such compounds as alcohol, carbon dioxide, and various acids. These agents act as preservatives on pickles, sauerkraut, salami, and some other foods.

Fumigation involves spraying foods with toxic gases to kill rats and insects. For example, methyl bromide gas is widely used to fumigate grain, dried fruit, and spices. Controlled-atmosphere storage creates conditions that help extend the storage life of foods, particularly fruit. The most common controlled atmosphere consists of 92 to 95 per cent nitrogen, 3 per cent oxygen, and 2 to 5 per cent carbon dioxide.

History

Early methods. Prehistoric people probably dried grains, nuts, fruit, roots, and other plant products in the sun. People who lived in northern climates probably kept food outside their caves or huts in the winter to prevent spoilage. In more southern climates, coolness inside caves was used to store foods. After fire was discovered, cave dwellers probably dried fish and meat over a fire. Drying by fire may have led to the development of smoking as a method of preservation.

Salt curing and fermentation are two other early methods of preservation. Ancient people salted meat and fish to prevent them from spoiling. Fermentation was used by nomadic peoples in Asia to make cheese.

Modern food preservation began in the 1700's. Lazzaro Spallanzani, an Italian naturalist, sealed meat extracts into glass flasks and heated them for an hour. Some of this food remained edible for several weeks.

By the early 1800's, Nicolas Appert, a sweet maker from Paris, had worked out a canning process in which food was packed in glass jars, which were then tightly corked, and heated in boiling water. Appert also published the first book on canning. Although Appert had made a major contribution to canning, he did not understand why his process worked. This understanding would have to wait about 50 years until the French chemist Louis Pasteur discovered that heat killed harmful microorganisms (see **Pasteur, Louis**).

Cold storage had been used for many years to preserve foods. But a method was needed to keep food cold in hot weather. At first, ice was cut from ponds and lakes during the winter and stored in buildings called *ice houses.* Sawdust was used to cover the ice and slow its melting in the summer. In 1851, the first commercial machine for making ice was patented by John Gorrie, an American doctor. This invention led to the large-scale use of refrigeration for preserving foods during shipping and storage.

Frozen foods were made possible by advances in refrigeration. In 1925, Clarence Birdseye, an American inventor, developed a quick-freezing process. He used refrigerated moving metal belts to quick-freeze fish.

Food was not dried in great volume until World War I (1914-1918), when dried food became important for feeding soldiers. The need for such food during World War II (1939-1945) led to the development of such items as instant coffee and dried milk.

Today, some people are concerned over the extent of food processing. They believe processing removes nutrients from food and that many additives are harmful to human beings. They recommend a return to natural foods that undergo a minimum amount of processing and that contain no chemical additives. However, food processors and manufacturers argue that food processing provides low-cost, nutritious foods. They also insist that chemical additives approved for use in food preservation are safe.

Related articles in *World Book* include

Methods of preserving food

Cold storage
Dehydrated food
Fermentation
Food, Frozen
Freeze-drying
Fumigation
Irradiation
Meat packing
Pasteurization
Refrigeration
Sterilization

Preservatives

Antibiotic
Dry ice
Food additive
Nitrate
Nitrite
Salt
Spice
Sugar
Sulphur dioxide
Vinegar

Other related articles

Bacteria
Birdseye, Clarence
Botulism
Enzyme
Fishing industry (Methods of processing)
Food poisoning
Jam and jelly
Mould
Pasteur, Louis
Spallanzani, Lazzaro
Yeast

Food service industry. See **Restaurant.**

The food supply in developing and industrial countries differs greatly, in many cases because of differences in farm output. On the left, farmers in Nepal receive a ration of rice seed, which will produce barely enough food for their needs. On the right, a U.S. farmer harvests a huge crop of soybeans.

Food supply

Food supply is the total amount of food available to all the people in the world. No one can live without food, and so the supply of food has always been one of the human race's main concerns. The food supply depends mainly on the world's farmers. They raise the crops and livestock that provide most of our food. The world's food supply varies from year to year because the production of crops and livestock varies. Some years, terrible losses result from droughts, floods, or other natural disasters. Yet the world's population grows every year, and so the worldwide demand for food constantly increases. Food shortages and famines occur when the food supply falls short of the amount needed.

The food supply varies not only from year to year but also from country to country. Most of the poor, *developing* countries of Africa, Asia, and Latin America seldom have enough food for most of their people. Millions of people in these countries go hungry. During years of famine, millions may die of starvation. In almost all *industrial* countries, on the other hand, the majority of people have an adequate diet. But in few countries is the food supply equally distributed. In nearly every country, some people have more than enough to eat while others live in constant hunger.

Most people in the industrial countries have an adequate diet for several reasons. Almost all the industrial countries lie in the world's *temperate* regions—that is, between the tropics and the polar areas. The soil and climate in the temperate regions are generally well suited to farming. In addition, the industrial countries have money for agricultural research and so have been able to solve various problems associated with agriculture in the temperate regions of the world. Most farmers in the industrial countries can afford the fertilizers and other materials needed to produce large amounts of food. Finally, the industrial countries have enough food because their population grows more slowly than their food supply.

Unlike the industrial countries, most developing countries lie in or near the tropics. The soil and climate in these regions are generally not so well suited to large-scale food production as they are in temperate regions. Nor do the developing countries have much money for research. As a result, they have made relatively little progress in solving the problems of tropical agriculture. In addition, many farmers in the developing countries cannot afford to buy the fertilizers and other materials they need to produce more food. All these conditions limit food production. But the developing countries have too little food chiefly because their population grows nearly as fast as—or faster than—their food supply.

The world's population reached $5\frac{3}{4}$ billion in the mid-1990's and is increasing by about 1.7 per cent a year. At this rate of growth, the number of people in the world will double in 41 years. Food production must also double during this time to feed the added people.

Many experts believe that food production will be unable to keep up with population growth unless the birth rate falls sharply. This theory was first developed in detail by the British economist Thomas Robert Malthus in the late 1700's (see **Malthus, Thomas Robert**). In the past, population growth was controlled mainly by a high death rate. But during the 1900's, improved living standards and medical advances have reduced the death rate in the majority of countries. Today, most people who agree with Malthus consider family planning to be the

only practical method of reducing population growth. This article discusses these and other food supply problems. It also discusses human food needs, food sources, and food supply programmes.

Basic human food needs

Experts usually determine the adequacy of a person's diet by the amount of *calories* and *protein* it provides. Protein is one of the chief *nutrients* (nourishing substances) found in food. It is needed to build and maintain body cells. Other nutrients are *carbohydrates* (starches and sugars), fats, minerals, and vitamins. Calories are units of energy supplied by food. Carbohydrates and fats normally provide most of the calories in the human diet. Protein supplies the rest. People who lack sufficient calories in their diet are said to be *undernourished.* A person whose diet seriously lacks any nutrient is said to be *malnourished.* Protein malnutrition is by far the most common type of malnutrition.

The majority of people who do not get enough protein in their diet also lack sufficient calories. To make up for a continuing lack of calories, the human body changes more and more protein into energy. As a result, less protein is available to build and maintain body cells. Most malnutrition is therefore protein-calorie malnutrition—an inadequate supply of both protein and calories in the diet. As many as 600 million people throughout the world—about one-ninth of the world's population—suffer from protein-calorie malnutrition. The great majority of these people live in developing countries, and most are young children. Many victims die before they are 5 years old. Many others grow up with severe mental and physical handicaps. See Nutrition (Protein-calorie malnutrition).

Calories. The amount of calories a person needs each day depends on the person's sex, age, body build, and degree of physical activity. A well-built house painter, for example, requires far more calories than does a slightly built office worker. The United Nations (UN) estimates that a moderately active man of average weight—that is, 65 kilograms—needs at least 3,000 calories a day. A moderately active woman of average weight—that is, 55 kilograms—needs about 2,200. Children and young people require an average of 820 to 3,070 calories, depending on sex, age, and weight.

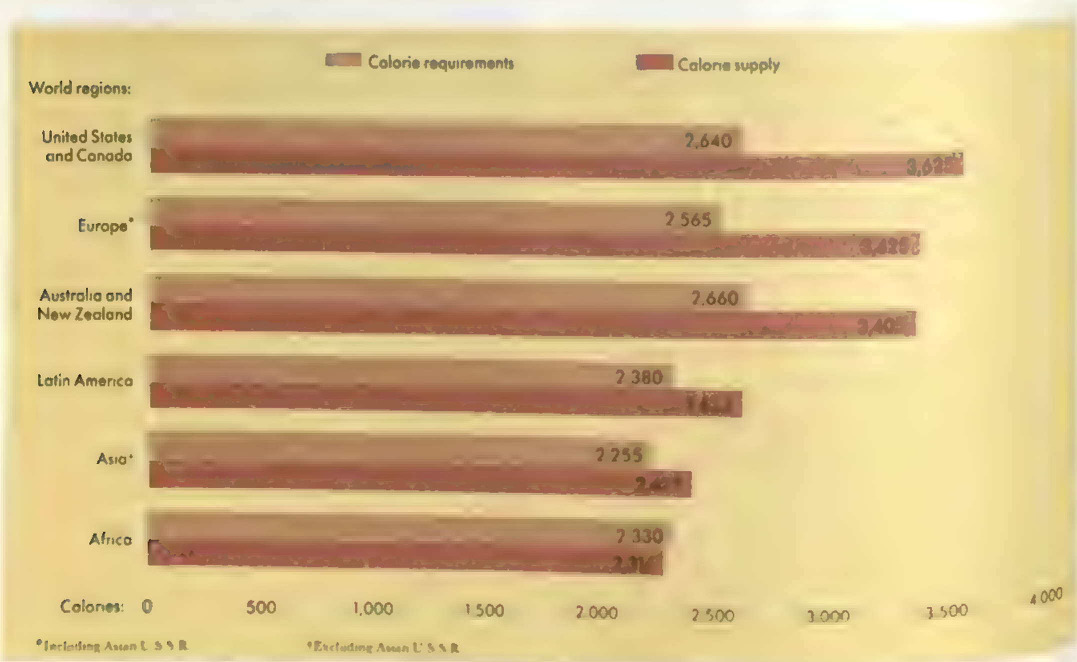
Daily calorie *consumption* (intake) by all people in the poorest industrialized countries averages under 2,000—far less than most people require. In some developed countries, daily calorie consumption averages over 3,700—far more than most people require.

Protein in the human diet consists of *animal protein* and *plant protein.* Dairy products, eggs, fish, and meat are the chief sources of animal protein. The best sources of plant protein are members of the pea family. These plants, which are called *legumes* or *pulses,* include beans, peas, and peanuts. *Cereal grains* also supply plant protein.

Protein is made up of molecules called *amino acids.*

Per capita distribution of the world's calorie supply

This graph shows the number of food calories that would be available daily *per capita* (for each person) in the world's major regions if the calories were divided equally among all the people in the region. It also shows the average number of calories required in each region. Calorie requirements depend on the average body weight of the population, the age and sex distribution, and the level of activity.



Figures are 1981-1983 averages. Source: *FAO Production Yearbook 1985* Food and Agriculture Organization of the United Nations

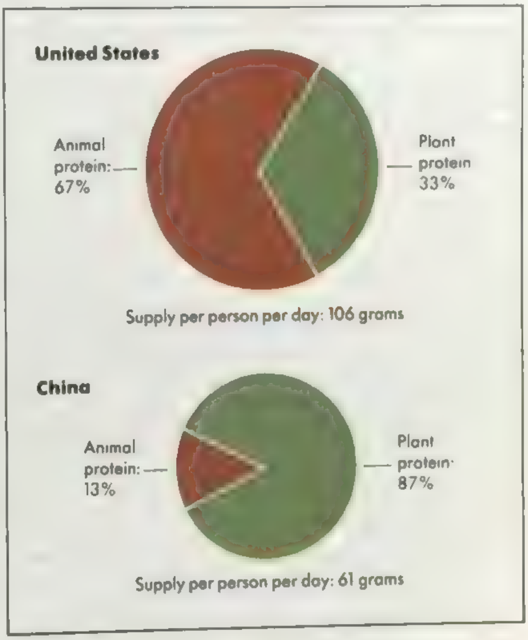
The human body must have certain amino acids to build and maintain body cells. Most sources of animal protein provide all the essential amino acids—and in the proportions the body requires. These food sources can thus supply all of a person's daily protein needs. On the other hand, many sources of plant protein do not supply the complete combination of amino acids. One or more of the essential amino acids are missing or insufficient. For example, cereal grains by themselves do not provide a full combination of amino acids. But if grain is eaten with certain legumes, especially protein-rich soybeans, it can meet a person's protein needs. See **Protein.**

People differ in their protein requirements, just as they do in their calorie requirements. But a person's protein needs also depend on the quality of the protein consumed. People require less protein if their diet includes some animal protein than if it includes only plant protein. The UN estimates that a man of average weight needs at least 37 grams of protein daily, if the protein is entirely animal protein. A woman of average weight needs about 29 grams. Children and young people up to 19 years of age require an average of 14 to 38 grams. In every case, a person's requirement increases if the protein is mainly plant protein.

Daily protein consumption by all people in the poorest developing countries averages as low as 33 grams. But most of the protein is plant protein. Average protein consumption in these countries therefore falls short of the minimum requirement. Also, most people in these countries have too few calories in their diet. As a result, much of the protein they consume is used to meet their energy needs rather than to build and maintain body cells. Protein consumption by all people in some industrialized countries averages as high as 107 to 119 grams daily. Most of the protein is animal protein and therefore far exceeds the minimum need. The extra protein provides added calories. If the calories exceed the amount required, the body stores the excess as fat.

Per capita protein supply in the United States and China

In the United States, an industrialized country, the daily per capita protein supply is almost twice as large as in China, a developing country. In addition, the per capita supply of animal protein in the United States is nine times as large as in China.



Major sources of food

Cereal grains are the world's most important food source. Worldwide, they supply about half the calories and much of the protein that people consume. Grain is also a chief ingredient in most livestock feed and so is involved in the production of meat, eggs, and dairy products. Cereal grains are of such great importance that food experts often use the size of the grain supply as a measure of the total food supply.

Almost all the grain grown in developing countries is *food grain*—that is, people consume it directly as food. They may simply cook the grain as a main dish. Or they may use it to make bread, noodles, or some other food. People in industrialized countries also consume grain directly. But in addition, they use much of the grain as *feed grain*, which is fed to livestock. People consume this grain indirectly in the form of livestock products.

Grains used chiefly as animal feed in some countries are used as food in other countries. For example, most of the maize grown in the United States is used for livestock feed. But in some African and Latin-American countries, maize is an important food grain.

Livestock and fish are the main sources of animal protein. On a worldwide basis, meat, eggs, and dairy products supply more than 80 per cent of the animal protein in the human diet. Fish provide a large percentage of the animal protein in certain countries, such as Japan, Norway, and the Philippines. But worldwide, fish supply only about 20 per cent of the animal protein people consume.

Other major food sources. In certain areas of the world, people depend heavily on food sources other than grain, livestock, or fish. Soybeans and other legumes rank second only to rice as a source of food in many Asian countries. Potatoes are a major food in parts of Europe and South America. People in some tropical areas rely largely on such native foods as bananas, *cassava* (a starchy root), and sweet potatoes or yams. Of all these foods, only legumes provide an adequate supply of essential amino acids.

Conditions that affect the food supply

The world's food supply consists mainly of food produced during the current year. But it also includes *reserves*, or *stocks*, left over from previous years. Food reserves are necessary to help prevent shortages after bad farming years. To build up reserves, the countries of the world overall must produce more food in a year than they consume. But few countries produce a surplus. The United States produces by far the largest surplus. Argentina, Australia, Canada, and New Zealand also regularly produce a food surplus.

Most countries produce either just enough food to meet their needs or not enough. If a country fails to produce enough food, it must import additional supplies or

face a shortage. Most industrialized countries that do not produce sufficient food can afford to import the extra supplies they need. Great Britain and Japan are examples of such countries. But most developing countries cannot afford to import all the food their people require. Since the early 1950's, world food production has doubled, but so has the demand. As a result, many countries rely on food imports, mainly from the United States.

The amount of food a country produces depends partly on its agricultural resources, such as land and water. No country has an unlimited supply of these resources. The worldwide food supply is thus affected by (1) limited agricultural resources and (2) the ever-increasing demand for food. The food supply within countries is also affected by problems of distribution.

Limited agricultural resources. Farming requires various resources—especially land, water, energy, and fertilizer. Land is the chief agricultural resource. Land used for growing crops must be fairly level and fertile. But most of the world's good cropland is already in use, and most of the unused land lies in remote areas, far from markets and transportation.

All crops require water to grow, but rainfall is distributed unevenly over the earth's surface. Some farmers can depend on rainfall for all the water they need. Other farmers must use irrigation water—if it is available—because the rainfall is too light or uncertain. But the supply of irrigation water is limited, and farmers in some countries use nearly all the available supply.

Many farmers depend heavily on energy resources—particularly petroleum fuels—to operate tractors, irrigation pumps, and other farm equipment. They use fertilizers—especially nitrogen fertilizers—to enrich the soil. At present, most nitrogen fertilizers are made from natural gas. But the world's supplies of petroleum and natural gas are strictly limited. In fact, the supplies may become extremely short or nearly exhausted by the early 2000's. Farmers will therefore need other sources for energy and nitrogen fertilizers.

Meanwhile, the energy needs of farmers have greatly increased. Between 1950 and 1985, the amount of energy used to produce a ton of grain more than doubled, rising from the equivalent of less than one half barrel of oil to more than one barrel. In some countries, the energy used to produce fertilizer exceeds that used to operate tractors. In every country, the generally rising prices of energy and fertilizer add to the cost of food.

Increased use of agricultural resources can help farmers produce more food. But it can also cause environmental problems. For example, increased use of nitrogen fertilizers sometimes creates a build-up of nitrogen compounds in the soil. Rain water eventually washes these compounds into rivers and streams, where they contribute to water pollution.

Increased demand for food chiefly reflects the growth in the population of the world. To a lesser extent, it also reflects higher living standards, which allow people to eat both bigger and better meals.

The effect of population growth. Experts measure a country's food supply by the amount that would be available *per capita* (for each person) if the food were distributed equally among all the people. The food supply thus depends not only on the total amount of food but also on the number of people who must be fed.

The industrialized countries increased food production by about 8 per cent from 1980 to 1985. During this period, the population of the industrialized countries grew by about 3 per cent. The amount of food available per capita in these countries therefore also increased. The developing countries increased their food production by about 16 per cent, and their populations grew by about 10 per cent from 1980 to 1985. Much of the increase in food production in developing countries was due to a large increase in China. Almost all of the other developing countries had little or no improvement in their per capita food production. In some developing countries, the population increases faster than the food production.

In an attempt to avoid disastrous food shortages in the future, many developing countries have promoted birth control programmes (see **Birth control**). But lack of education and various other social and economic obstacles have prevented the programmes from reaching or influencing most of the people.

The effect of higher living standards. As people improve their living standards, especially through increased personal income, they usually eat more food. In

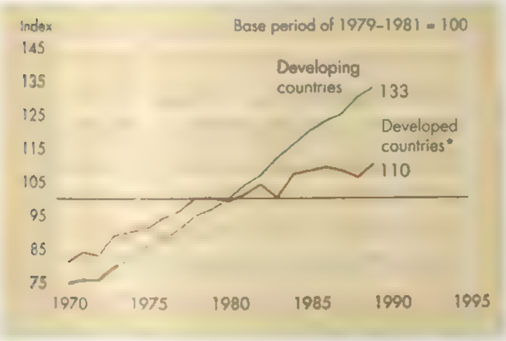
The relation between food production and population

This graph shows the percentage contributions to world food production and world population of each major world region. Asia, Africa, and Latin America have over 75 per cent of the world's people but produce only about 50 per cent of its food.

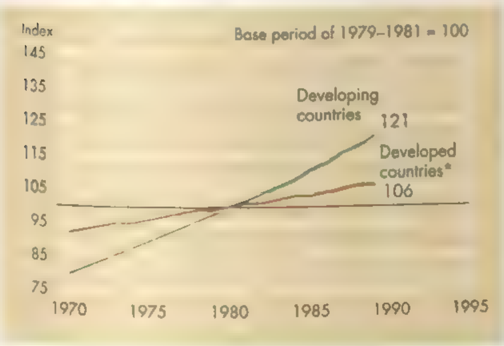
Figures are for 1985. Source: United Nations

The growth in food production and population

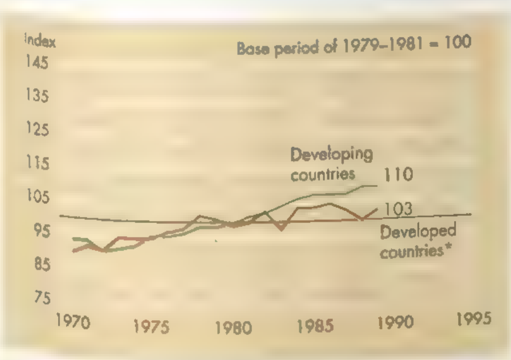
Developing countries have increased their food production at a faster rate than industrial countries since 1970. But the population of developing countries has also increased at a faster rate. As a result, the *per capita* (per person) increase in food production has been nearly the same in the two groups of countries.



Growth of food production has been greater in developing countries than it has been in industrial countries. The difference has widened since 1980 because of a large increase in production in China, a developing country.



Population growth has been consistently higher in developing countries than it has been in industrial countries.



Growth in per capita food production has been nearly the same. This is because the faster growth in food production in developing countries is balanced by faster population growth.

*According to the United Nations, the industrial countries are Australia and New Zealand, Canada and the United States, Israel, Japan, South Africa, and all European countries. The former Soviet Union is counted as a European nation. All other countries are developing countries.
Source: Food and Agriculture Organization of the United Nations.

time, they also generally begin to eat more expensive foods, particularly more meat. Greater meat consumption usually calls for an increase in the amount of grain used for livestock feed. For this reason, many countries with a high standard of living also have a high per capita consumption of grain.

The people of the United States, for example, consume an average of about 68 kilograms of grain per person annually. But about 680 kilograms of grain per person is fed to U.S. livestock each year. Americans consume this grain indirectly in the form of meat, eggs, and dairy products. Total per capita grain consumption in the United States thus averages about 748 kilograms annually.

Total per capita grain consumption in the developing countries averages about 180 kilograms a year. Almost all this grain is consumed directly. On average, people in industrial countries consume more than four times as much grain as do people in developing countries.

Distribution problems. In many developing countries, the majority of people are too poor to buy all the food they need. Much of the available supply therefore goes to the small minority of people who can afford it. The developing countries also lack modern facilities for the transportation and storage of food. In many cases, supplies cannot be delivered immediately to every area where they are needed, and they cannot be safely stored to await shipment. As a result, large quantities of food spoil or are eaten by mice, rats, and insects.

Methods to increase the food supply

Most increases in the food supply result from greater farm output. Farm output can be increased in two main ways: (1) by developing new farmland and (2) by making existing farmland more productive. Two other methods involve (1) reducing the demand for feed grain and (2) developing new sources of food.

Developing new farmland is difficult and costly. The largest areas of land that could be developed for farming lie in Africa south of the Sahara and in the Amazon River Basin of South America. Much of this land is covered with dense forests, and the tropical soil and climate are not ideal for farming (see **Tropical rainforest**). As a result, it is difficult to get farmers to settle and develop the land.

Making farmland more productive. Farmers have two main methods of making their land more productive. (1) They may increase their use of irrigation, energy, and fertilizer. (2) They may use improved varieties of grains and livestock, which produce higher crop yields and larger amounts of livestock products. Farmers in industrialized countries have used both methods during much of the 1900's. In the 1950's and 1960's, farmers in some developing countries also adopted both methods to increase their production of wheat and rice. Their effort proved so successful that it has been called the *Green Revolution.*

The development of high-yield varieties of rice and wheat made the Green Revolution possible. But the revolution also required greater use of irrigation water, energy, and fertilizer. Many farmers got the water from wells and installed electric or diesel-powered pumps to bring the water to the surface. To get the highest yields, farmers had to enrich their soil with fertilizers. During

the 1960's, these methods helped such countries as India and Mexico double their wheat production.

The Green Revolution can continue to make farmland more productive. For example, if farmers in the tropics have enough water, fertilizer, and other essential resources, they can grow two or three crops a year on the same land, instead of one crop. But the Green Revolution's ability to increase the food supply is limited. Many farmers in developing countries cannot afford the additional resources that the Green Revolution requires. But in any case, greater use of these resources makes land more productive only up to a point. Most farmers in the United States, for example, use 7 to 10 times as much fertilizer on each unit of land as do most farmers in developing countries. But U.S. grain yields are only about twice as large as those in developing countries.

Although farmland can be made more productive, the ever-rising costs of energy and fertilizer drive food prices higher and higher. And millions of people throughout the world cannot afford to buy all the food they need even at lower prices. Ways must therefore be found to expand food production at a cost that most people can afford.

The best hope for making farmland more productive lies with agricultural research. For example, research scientists are working to develop varieties of grain that not only produce higher yields but also have other improved characteristics. Such a grain might supply a more complete combination of amino acids, make more efficient use of water and fertilizer, and provide better resistance to insects and disease. But it is extremely difficult to develop a plant variety that has so many different characteristics. The necessary research therefore takes much time and money.

Reducing the demand for feed grain would increase the amount of calories and protein available for human consumption. This increase would occur because livestock consume more calories and protein than they produce. Beef cattle are especially inefficient in this respect. On average, for every 3.6 to 4.5 kilograms of grain that beef cattle consume, they produce only about 0.45 kilogram of meat. But about 4 kilograms of grain supplies around 10 times as many calories and more than 4 times as much protein as half a kilogram of beef supplies.

Research in tropical agriculture seeks to increase food production in developing countries, most of which lie in the tropics. This researcher in India is studying tropical plant diseases.

In the past, almost all beef cattle grazed on grass and other *forage* up to the time they were slaughtered. But since the mid-1900's, many cattle-fattening establishments called *feed lots* have opened in Australia, Canada, the United States and certain other industrialized countries. A feed lot fattens cattle on grain. Today, most U.S. beef cattle are fattened on feed lots and so consume enormous quantities of grain. The demand for feed grain would lessen greatly if the cattle industry returned to its earlier practice of raising cattle chiefly on forage. In the United Kingdom and the rest of Europe cattle tend to be fed on grass silage or rolled barley rather than grains such as maize. But relying on forage supplies will not always produce enough beef to satisfy demand. The demand for feed grain would also decline if people in the industrialized countries ate less meat.

Developing new sources of food. Such oilseed crops as coconuts, cottonseed, peanuts, and soybeans are all valuable sources of protein. Soybeans have an especially high protein content and have long been an important food in Asia, where they originated. But with this exception, none of these oilseed crops is a major source of food anywhere in the world. Instead, the crops are grown mainly for their oil, which is used to make such products as margarine and salad dressing. The protein, however, remains in the meal, the part of the seed that is left after the oil has been removed. Most of the meal is used for livestock feed.

Since the mid-1900's, food processors have been working to make the protein in oilseed meal available for human consumption. They have developed a variety of inexpensive, specially flavoured foods from soybean meal. Some of these products, especially those in beverage form, have been successfully marketed in developing countries in various parts of the world. Food processors are now working to convert coconut, cottonseed, and peanut meal into foods that will have a broad appeal. All three crops are widely grown in the tropics and so could provide millions of people in developing countries with inexpensive protein.

Scientists and food processors have also developed methods of enriching food. For example, scientists have produced artificial amino acids, which can be added to bread and other grain products to improve the quality of their protein.

Food supply programmes

Various organizations sponsor programmes to increase and improve the world's food supply. The chief international organizations include two United Nations (UN) agencies—the Food and Agriculture Organization (FAO) and the World Bank. The World Food Council, a group of food experts appointed by the UN, helps coordinate the work of the various international organizations. Many industrialized countries have set up their own agencies to help increase the world's food supply.

Emergency food supplies are provided for thousands of disaster victims annually. These Red Cross workers are distributing emergency rations to victims of a flood in Bangladesh.

There are a number of important food supply programmes that are sponsored by religious groups, other private groups, and charities. For example, the Rockefeller Foundation, a philanthropic organization founded in the United States by the Rockefeller family, has long been one of the biggest contributors to agricultural research in developing countries. Charitable organizations such as Oxfam also support agricultural research, and supply food relief during periods of famine in developing countries.

Technical and financial programmes work to expand farm output in developing countries. The Food and Agriculture Organization sponsors the chief technical assistance programmes. These programmes are designed mainly to train farmers in modern agricultural methods. The United Nations Development Program also sponsors technical aid programmes (see **United Nations** [Economic and technical aid]).

Most financial help for agriculture in the developing countries is in the form of low-interest loans. The World Bank and various regional banks associated with the World Bank provide most of the loans. In 1976, the UN established the International Fund for Agricultural Development to obtain additional loan funds from prosperous UN members.

Food aid programmes provide shipments of food to countries that need emergency aid. Western industrialized countries and Japan contribute most of this aid. The United States is the largest contributor. Most of the assistance given by the United States is administered through the federal government's Food for Peace programme. The World Food Program, sponsored by the UN and the FAO, channels donations from individual countries to nations in need of aid. Many private charitable organizations also supply food aid. World charity events, such as Bob Geldof's Band Aid Concert of 1986 in London, have successfully raised money for food aid to Africa and other developing countries.

Research programmes. Various scientific research programmes seek to increase both the quality and the quantity of the food supply. For example, a variety of maize with an improved amino acid content was developed in the 1960's. But the new variety gives relatively low yields. Scientists are now working to develop a high-yield variety with the improved amino acid content.

Research scientists are also seeking ways to conserve agricultural resources. As we have seen, some of this research is aimed at developing varieties of grain that make more efficient use of water and fertilizer. Animal scientists are conducting similar experiments to develop varieties of cattle that produce more meat from the same amount of feed.

Many research projects are carried out at about 10 agricultural research institutes jointly sponsored by the FAO, the World Bank, the Ford and Rockefeller foundations, and several other organizations. The institutes have been established in developing countries, and each specializes in a particular type of research. In Mexico, for example, the International Centre for the Improvement of Maize and Wheat is trying to produce improved varieties of maize, wheat, and certain other grains. Some of the institutes, such as the International Institute of Tropical Agriculture in Nigeria, are working to develop varieties of plants and livestock that are specially suited to tropical climates.

A world food reserve. In 1974, representatives from 130 countries attended a UN-sponsored World Food Conference in Rome. At the conference, the representatives adopted a plan to set up a unified world food reserve. The world's reserves now consist of the individual reserves of the major exporting countries. Each country administers its own reserve. Under the new plan, each country will continue to hold its own reserve, but it will work with participating countries in the use of the reserve. Reserve food supplies can thus be directed to the parts of the world where they are needed most.

Related articles. See **Agriculture, Food,** and **Nutrition** and their lists of *Related articles.* See also the following articles:

Birth control
Famine
Fishing industry
Food and Agriculture Organization
Population
Standard of living
United Nations (Fighting hunger)
World Bank

Outline

I. Basic human food needs
A. Calories
B. Protein
II. Major sources of food
A. Cereal grains
B. Livestock and fish
C. Other major food sources
III. Conditions that affect the food supply
A. Limited agricultural resources
B. Increased demand for food
C. Distribution problems
IV. Methods to increase the food supply
A. Developing new farmland
B. Making farmland more productive
C. Reducing the demand for feed grain
D. Developing new sources of food
V. Food supply programmes
A. Technical and financial programmes
B. Food aid programmes
C. Research programmes
D. A world food reserve

Questions

Why do most developing countries seldom have enough food?
What are four methods to increase the food supply?
What plants are the most important source of food?
What is protein-calorie malnutrition?
Which country produces the most surplus food?
How do higher living standards affect the food supply?
What is the Green Revolution?
How would a reduction in the demand for feed grain increase the food supply? Why?

Food value. See Nutrition.

Food web. See Ecology (Ecosystems); Fish (Fish in the balance of nature).

Fool's gold. See Pyrite; Mineral (picture).

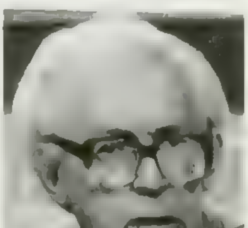
Foot is the name of three brothers who became British politicians. They were born in Plymouth, England.

Sir Dingle Mackintosh Foot (1905-1978) was solicitor general from 1964 until 1967. He was a Liberal member of Parliament from 1931 to 1945. In 1956, he joined the Labour Party. The next year, he became the Labour member of Parliament for Ipswich.

Sir Hugh Mackintosh Foot (1907-1990), Lord Caradon, was minister of state at the Foreign Office and permanent British representative at the United Nations from 1964 to 1970. He entered colonial administration in 1928 and was governor of Cyprus from 1957 to 1960. In 1961, he became Britain's ambassador to the United Nations. He was made a life peer in 1964.

Michael Foot (1913-) was leader of the Labour Party from 1980 to 1983. He is a member of the party's left wing. The left wing calls for increased government spending on social welfare programmes and for government ownership of businesses.

Foot was born in Plymouth, England, and attended Oxford University. He became a newspaper columnist and editor and a forceful left-wing critic of British government policies. From 1945 to 1955, Foot represented a district of Plymouth in the House of Commons. He has represented the Ebbw Vale district of Wales since 1960. He was secretary of state for employment from 1974 to 1976. In 1976, he became deputy prime minister and leader of the House of Commons. He was appointed to these offices following James Callaghan's election as Labour Party leader by the party's members of Parliament. Callaghan became prime minister as a result of the election. Foot had received the second largest number of votes. His term in the offices ended in 1979, when the Conservative Party won control of the government. Callaghan resigned as Labour Party leader in 1980, and the party's members elected Foot to succeed him. Foot resigned as party leader in 1983.



Michael Foot

Foot is the structure at the end of the leg, on which humans and some animals stand. In animals that walk on all four legs, the ends of the front and hind limbs, or feet, are much the same. In humans, birds, and animals such as the kangaroo that walk on their hind limbs, the foot is heavier and stronger than its counterpart on the forelimb, the hand.

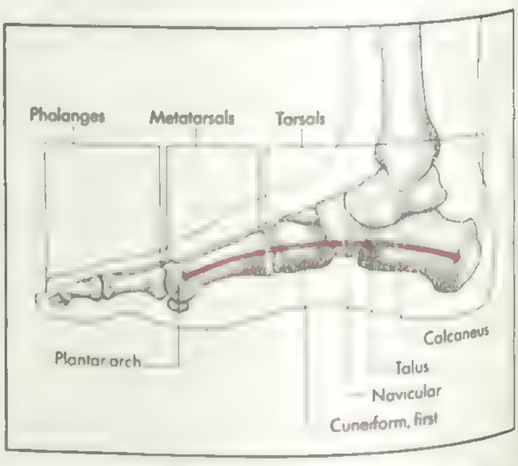
The bones. The human foot has 26 bones. They are (1) the seven *tarsals,* or ankle bones; (2) the five *metatarsals,* or instep bones; and (3) the 14 *phalanges,* or toe bones. The tarsal bones are the *talus, calcaneus, navicular, cuboid,* and the three *cuneiform* bones. They form the heel and back part of the instep. The metatarsal bones connect the cuneiforms and the cuboid with the phalanges, and form the front part of the instep. The big toe has two phalanges. Each of the other toes has three. The ends of the phalanges meet the underside of the metatarsals to form the *ball of the foot.*

The arches. The bones of the foot form three arches, two running lengthwise and one running across the instep. The arches provide the natural elastic spring of the foot in walking or jumping. The main arch reaches from the heel bone to the ball of the foot. It is called the *long medial* or *plantar* arch. This arch touches the ground only at the heel and ball of the foot and thus acts as a shock absorber for the leg and spinal column. A thick layer of flexible cartilage covers the ends of the bones of the arch (see **Cartilage**). The cartilage helps make the arch shock-absorbent. The *lateral* arch runs along the outside of the foot, and the *transverse* or *metatarsal* arch lies across the ball of the foot. The condition known as *flatfoot* may be caused by the breakdown of the arches of the foot (see **Flatfoot**).

Ligaments and muscles support the arches of the foot. The long plantar ligament, called the *plantar fascia,* is very strong. It keeps the bones of the foot in place and protects the nerves, muscles, and blood vessels in the hollow of the foot. The foot has as many muscles as the hand. But its structure permits less flexibility and freedom of movement than does that of the hand.

Tough, thick skin covers the *sole,* or bottom, of the foot. A thick pad of fatty tissue lies between the skin and the bones and the plantar ligament. This layer of fat acts like an air cushion to protect the inner parts of the foot from pressure on the foot and from jarring.

Disorders of the foot, such as corns, may result from wearing badly fitted shoes.



The foot has three sets of bones—the *tarsals,* or ankle bones; *metatarsals,* or instep bones; and *phalanges,* or toe bones. The *plantar arch* extends from the heel to the ball of the foot.

Related articles in *World Book* include:

Achilles' tendon	Chilblain
Animal (picture: Kinds of feet)	Chiropody
Ankle	Clubfoot
Athlete's foot	Corn
Bunion	Footprinting
Callus	Immersion foot

Foot, in poetry. See **Poetry** (Rhythm and metre).

Foot is a unit of length in the inch-pound system of measurement customarily used in many English-speaking countries. It is equal to one-third of a yard, and contains 12 inches. A 1959 international agreement defines the yard in a way that makes the foot equal to exactly 0.3048 metre. See **Weights and measures.**

A *square foot* is a unit of area. It is equal to the area of a square whose sides are 1 foot long. It contains 12 × 12, or 144, square inches (about 929 square centimetres). A *cubic foot* is a unit of volume. It is equal to the volume of a cube 1 foot high, 1 foot wide, and 1 foot deep. It contains 12 × 12 × 12, or 1,728 cubic inches (about 28,317 cubic centimetres). The symbol for foot is ′.

The foot measurement began in ancient times based on the length of the human foot. By the Middle Ages, the foot as defined by different European countries ranged from 10 to 20 inches. In 1305, England set the foot equal to 12 inches, where 1 inch equalled the length of "three grains of barley dry and round."

Foot-and-mouth disease is a highly contagious disease of animals. It is also called *hoof-and-mouth disease,* though the infection does not actually involve the horny hoof, but rather the tissues around it. Foot-and-mouth disease attacks cattle, goats, pigs, sheep, and other mammals that have *cloven* (split) hoofs. It occurs among livestock in many regions of the world, particularly in Africa, Asia, Europe, and South America. The disease is rare in Australia and North America.

Cause and symptoms. Foot-and-mouth disease is caused by a virus. Healthy livestock may contract the disease through contact with infected animals or with objects that have been contaminated by saliva or body wastes from infected animals. The virus may also be spread by wind or by birds, rats, cats, and many other animals that are not themselves affected by foot-and-mouth disease.

Foot-and-mouth disease produces blisters in the mouth, in the tissue between the split in the hoof, and on the upper part of the foot. Infected animals also develop a high fever. They drool, have trouble walking, and lose weight rapidly. In female animals, the virus also affects the udders and the milk-producing mammary glands, causing a drop in milk production. In severe cases, the virus attacks the heart, causing death. The death rate may reach 100 per cent among young cattle and pigs, but it rarely exceeds 10 per cent among adult livestock. However, the decrease in meat and milk production by adult animals results in great economic losses.

Measures of control. There is no cure for foot-and-mouth disease, but countries use a variety of methods to control it. In the African, Asian, European, and South American countries where the disease is *endemic* (found regularly), it is controlled chiefly through the use of vaccines. Most vaccines protect the animals for only a short period, and so must be administered several times a year. In addition, the vaccines are expensive and, in some cases, they contain live viruses that may infect the animals. In 1981, American scientists used genetic engineering techniques to develop a safer and less costly vaccine (see **Genetic engineering**).

In countries where the disease is not endemic, it is controlled chiefly through import restrictions and quarantine procedures. Such measures normally prevent the introduction of the virus. These countries also have policies for eliminating the disease should an outbreak occur. Most such policies call for slaughtering the infected animals, burying or burning their carcasses, and decontaminating the area in which the animals lived.

Foot-candle is a unit of measurement of *illumination,* the amount of light that falls on an object. The foot-candle is part of the customary, or English, system of measurement.

Two factors determine the amount of light that an object receives: (1) the *luminous intensity* (brightness) of the light source and (2) the distance between the light source and the object. As the luminous intensity of the light source increases, illumination of the object also increases. As the distance increases, illumination of the object decreases.

To calculate foot-candles (*fc*), scientists use the formula $fc = \frac{Cd}{D^2}$. *Cd* is the luminous intensity of the light, measured in *candelas* (see **Candela**). *D* is the distance in feet between the light source and the object.

In the metric system, units of measurement for illumination include the *lux* and the *phot.* Distance is measured in metres to calculate luxes, and in centimetres to calculate phots. One lumen is equal to an illumination of one lumen per square metre. One phot is equal to an illumination of one lumen per square centimetre, or 10,000 lumens per square metre.

See also **Light** (The brightness of light; diagram: Basic units of light measurement); **Lighting** (Quantity of light).

Foot-pound is a unit of work and energy in the customary, or English, system of measurement. Physicists define *work* as the product of force and distance when a force moves an object a certain distance. One foot-pound is the amount of work done when a force of 1 pound moves an object a distance of 1 foot. If a force of 2 pounds moves an object 3 feet, the work done equals 6 foot-pounds. *Energy* is the ability to do work. The foot-pound is used to measure all forms of energy. One foot-pound equals the quantity of energy needed to lift a 1-pound object to a height of 1 foot. Thus, 6 foot-pounds of mechanical energy are needed to lift a 2-pound object 3 feet high.

The rate at which work is done is called *power.* To measure power, the amount of time required to do the work is considered along with force and distance. Power may be measured either in foot-pounds per second or in horsepower. One horsepower equals 550 foot-pounds per second (see **Horsepower**).

In the metric system of measurement, work and energy are measured in *joules.* One foot-pound equals 1.356 joules.

See also **Energy** (Measuring energy); **Joule; Work.**

Football. See **Football, American; Football, Association; Football, Australian Rules; Football, Gaelic; Rugby football** (Rugby Union; Rugby League).

Action-packed plays make football an exciting game. On the play above, the defending team, wearing red jerseys, tries to stop the ball carrier, wearing white, from advancing the ball.

Football, American

Football, American, is an exciting team sport played chiefly in the United States and Canada. It is played by elementary school, high school, college, and professional teams. Millions of people crowd stadiums each football season to watch their favourite teams. Millions more watch televised games between college teams and teams in the two major professional leagues, the National Football League (NFL) of the United States and the Canadian Football League (CFL).

In the United States, football is played by two teams of 11 players each. Canadian teams have 12 players. Each team tries to score points, mainly by running or passing *plays* (manoeuvres) that move an oval ball across the opposing team's goal line. Such a run or pass scores a touchdown. During a game, possession of the ball shifts from team to team. The team with the ball is the *attacking team.* The other team is the *defending team.* It tries to prevent the attacking team from scoring.

A good American football team combines strength and speed. Physical contact, especially involving blocking and tackling, is a basic part of American football. The sport also requires quick reactions and thorough preparation for each game. In addition, split-second teamwork is essential. All the players on a team must work together to defeat their opponents.

American football originated in the United States. It began to develop during the mid-1800's. The sport grew out of *Association football* (or *soccer*) and rugby, two kicking games that were developed in England.

This article deals chiefly with American football as played in the NFL in the United States. The game differs somewhat in Canada.

The field and equipment

The field. American football is played on a level area 120 yards (110 metres) long and $53\frac{1}{3}$ yards (49 metres) wide. Outdoor fields have a surface of grass or a synthetic material. Indoor stadiums use green synthetic surfaces that look like grass.

Football terms

Blitz is a defensive manoeuvre in which one or more linebackers and defensive backs charge through the line of attack and try to tackle the quarterback before he can pass or hand off the ball.

Draw is a running play in which the quarterback fakes a pass and then hands the ball to a running back.

Field position refers to the location of the ball on the field. If the attacking team has the ball near its opponent's goal line, it has good field position. If the attacking team has the ball near its own goal line, it has poor field position.

Option is an attacking play in which the quarterback runs along the line of scrimmage with the choice of keeping the ball or tossing it to a running back.

Prevent defence refers to a defending formation that includes extra defending backs to provide additional protection against an expected long pass.

Rollout is a passing play in which the passer retreats a short distance behind the line of scrimmage and then runs toward a sideline before throwing the ball. This helps the passer avoid tacklers, giving him more time to find a receiver.

Sack is the tackle of a quarterback before he can throw a pass.

Screen pass is a play in which the quarterback retreats behind the line of scrimmage and then tosses a short pass to a receiver waiting behind several blockers.

Sweep means a running play around either end.

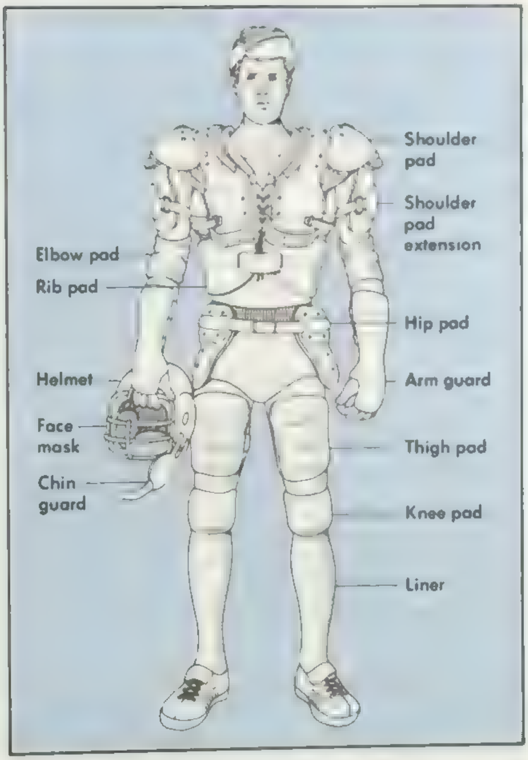
Trap is a running play in which the line of attack allows a defensive lineman into the backfield and blocks him from the side. The ball carrier then runs through the hole left by the blocked lineman.

The football field is marked with white lines. It is often called a *gridiron* because the pattern of lines resembles the cooking utensil used to grill foods. A *sideline* borders each of the two long sides of the field. Any player who touches or crosses a sideline is ruled out of bounds. *Yard lines* cross the field every 5 yards (4.6 metres). Near each end of the field is a *goal line*. The goal lines are 100 yards (91.4 metres) apart. An area called an *end zone* extends 10 yards (9.1 metres) beyond each goal line. The yard lines are numbered from each goal line to the 50-yard line, or *midfield*.

Two rows of lines, called *hash marks*, parallel the sidelines. In NFL games, the hash marks are 70 feet 9 inches (21.6 metres) from each sideline. All plays start with the ball between or on the hash marks. If a play ends out of bounds or between the hash marks and the sideline, the ball is placed on the nearest hash mark for the next play. The goal posts are 18½ feet (5.6 metres) apart and rise 30 feet (9 metres) from the crossbar. A single post 6 feet (1.8 metres) behind the end line curves forward and supports the crossbar over the end line.

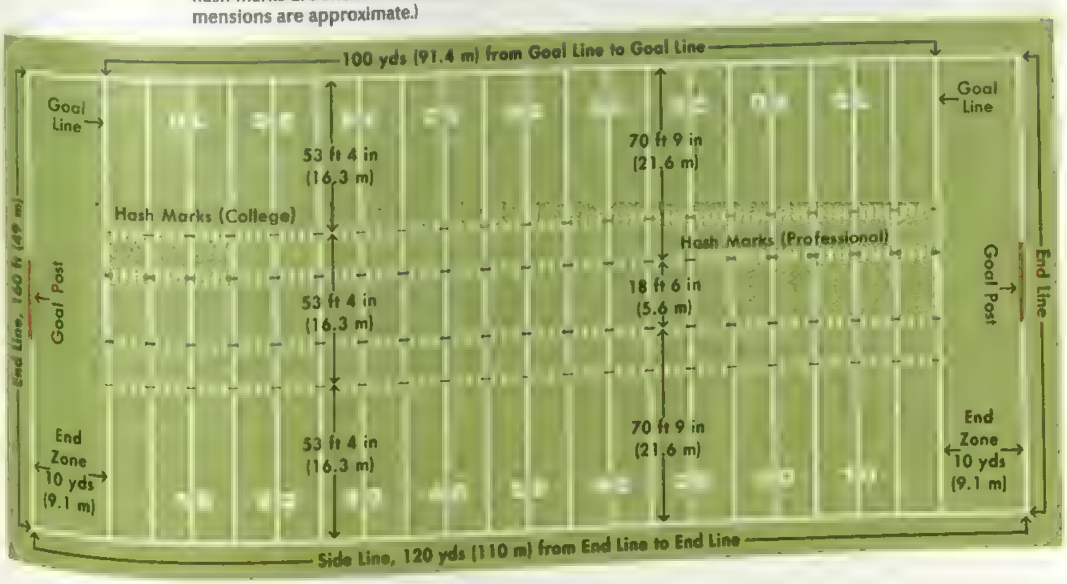
The ball is oval. It is about 11 inches (28 centimetres) long and 7 inches (18 centimetres) in diameter at the centre. Balls used in NFL games are made of four pieces of leather stitched together. Balls used in recreation may be made of rubber or plastic. A football has a rubber lining, which is inflated to an air pressure of 12½ to 13½ pounds per square inch (0.88 to 0.95 kilogram per square centimetre). The ball weighs 14 to 15 ounces (397 to 425 grams). Leather laces along one seam provide a grip for holding and passing the ball.

The uniform. A football player's uniform is made of cotton or nylon and consists of a shirt and pants. The shirt, called a *jersey*, has the player's number—and sometimes his name—sewn on the back and front for identification. In most cases, the players wear jerseys and pants of different colours.



Protective equipment helps prevent injuries. The amount and type of padding depend on a player's position. Linemen wear the most padding because they do the most blocking and tackling. Backs and ends wear less so they can move more easily.

Diagram of a U.S. football field The football field is marked with white lines. Yard lines cross the field every 5 yards (4.6 metres). Hash marks run down the field across the yard lines. NFL hash marks are shown in blue. (College hash marks are shown in red.) Goal posts stand on the end lines behind the goal lines. (Metric dimensions are approximate.)



Protective equipment helps prevent injuries. The equipment a player wears depends on his position. Linemen wear more protective equipment than other players because they are involved in the most physical contact through blocking and tackling. Backs and ends wear less equipment so they can run at speed.

Each player wears a helmet held in place with a chin guard. The helmet has a face mask. Most players also wear a mouthpiece to help prevent injuries to their teeth. Under their uniforms, the players wear shoulder pads, hip pads, thigh pads, and knee pads. In many cases, the thigh pads and knee pads are sewn into the pants. Some players also use arm guards, elbow pads, rib pads, and liners to protect the shins.

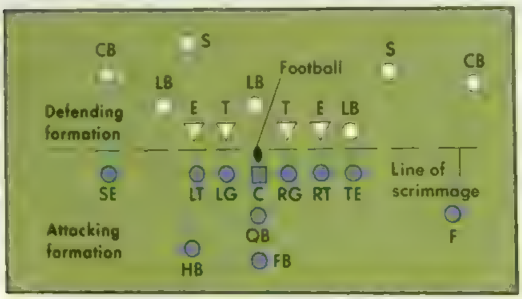
The players and coaches

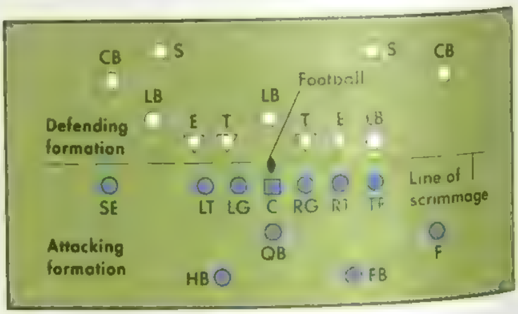
Every football team has some players who play attack and others who play defence. Before each play, the attacking and defending teams face each other along the *line of scrimmage.* This imaginary line aligns with the spot where the preceding play ended, and parallels the yard lines and passes through the tip of the ball nearest each team's goal. Thus, each team has its own line of scrimmage, separated by the length of the football. The area between the two lines is called the *neutral zone.*

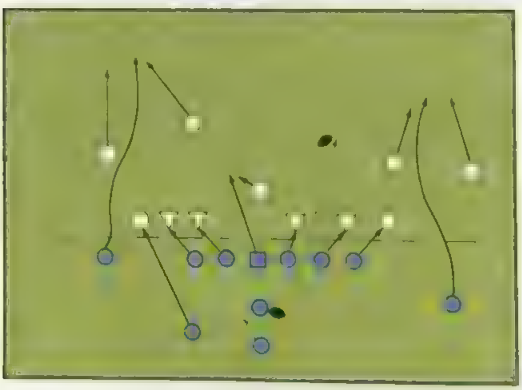
The attacking team consists of seven *linemen* and four *backs.* The team must have at least seven players on the line of scrimmage before a play. The linemen are divided into five *interior linemen* and two *ends.* The interior linemen consist of a *centre,* two *guards,* and two *tackles.* They block for the ball carriers, passers, and pass receivers. The centre also *snaps* (gives) the ball through his legs to the quarterback to begin a play.

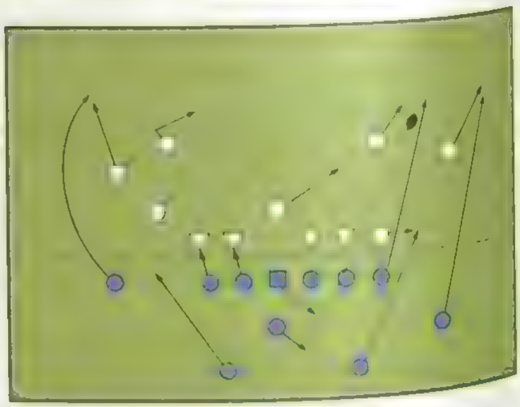
Each of the two ends plays a position on the outside of the interior linemen. The chief job of the ends, like that of the interior linemen, is to block. However, ends may also receive passes. Occasionally, an end may even carry the ball. Many attacking *formations* (arrangements of players) have two types of ends: (1) the tight end and (2) the split end, or wide receiver. The tight end lines up near the tackle. Although the tight end serves as a pass receiver, he also has important blocking responsibilities. The split end stands on the side of the line of scrimmage opposite the tight end and several metres from the tackle. The split end is used mainly as a pass receiver.

The four backs make up the *backfield,* which generally consists of a *quarterback,* two *halfbacks,* and a *fullback.* In the standard *T-formation,* the fullback lines up 3 to 5 paces behind the quarterback and has a halfback









A running play may go through various areas. The play above calls for the fullback to run the ball between his right guard and right tackle. The fullback gets the handoff from the quarterback and cuts back to his right. The linemen and halfback block defending linemen and linebackers. The flanker and split end run down-field to decoy the defending backs into expecting a pass.

A passing play requires split-second timing. The play above calls for the linemen and halfbacks to block while the quarterback passes to the tight end. If the tight end is covered, the quarterback can pass to the split end or the flanker. Even if his blockers give him good protection from the defence, the passer has only a few seconds to select a receiver and throw the ball.

Key to positions SE = Split End; LT = Left Tackle; LG = Left Guard; C = Centre; RG = Right Guard; RT = Right Tackle; TE = Tight End; HB = Halfback; QB = Quarterback; F = Flanker; FB = Fullback; E = End; T = Tackle; LB = Linebacker; CB = Cornerback; S = Safety

on each side. The backs also have other names. A fullback used chiefly as a blocker is a *blocking back.* A halfback who lines up outside the tight end is called a *flanker* or a *wingback.* A halfback who usually carries the ball is a *running back.*

Most interior linemen are bigger and stronger than backs and ends because they must block against large defending linemen. Most backs and pass receivers are smaller than linemen but faster and more agile.

The defending team is divided into three units: (1) the line, (2) the linebackers, and (3) the secondary.

The line may have as many players as the defending team chooses. But most teams use three, four, or five players. A three-man line consists of a *middle guard,* also called a *nose guard,* and two *ends.* A four-man line, called the *front four,* consists of two *tackles* and two *ends.* A five-man line consists of a *middle guard,* two *tackles,* and two *ends.* The defending linemen use their size, strength, and power against attacking blockers.

The linebackers position themselves 2 or 3 paces behind the linemen. A team that uses a four-man line will normally have three linebackers. The player who lines up facing the centre is the *middle linebacker.* The two other players, called *outside linebackers,* stand outside the defending ends. Four linebackers are used with a three-man line, and two are used with a five-man line. In certain defensive formations, the linebackers will move up to the line of scrimmage with the linemen.

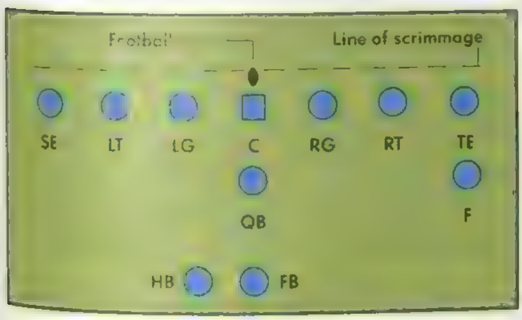
Linebackers, especially middle linebackers, make many tackles. They must combine strength with the ability to move quickly to wherever the ball carrier is running. They must also be good pass defenders.

The secondary is made up of two *cornerbacks* and two *safeties.* They are often called *defending backs.* Their chief task is to defend against the opponents' passing attacks. They also try to tackle ball carriers who have passed the linemen and linebackers. Defending backs must be fast enough to cover speedy pass receivers, and they must be especially sure tacklers.

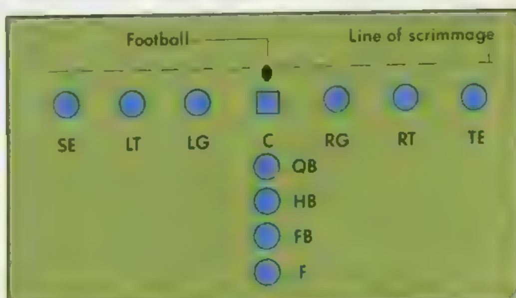
The cornerbacks stand about 7 to 9 paces behind the line of scrimmage, at the corners of the defensive formation. They defend against short passes thrown toward the sidelines. Safeties play about 7 to 11 paces behind the line of scrimmage and defend against long passes. Sometimes, secondaries use *double coverage,* in which two defending backs cover one receiver.

Attacking and defending formations

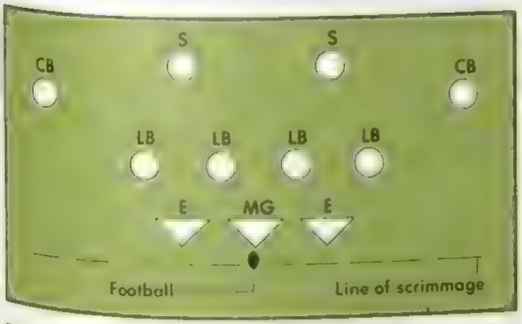
Before each play, the teams line up in attacking and defending formations on the line of scrimmage. Some offensive formations are more effective for passing, and others are more effective for running. The defence selects a formation best able to stop the play it believes the offence will try.



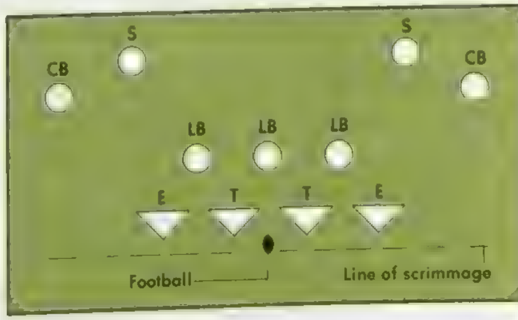
The winged T is a popular attacking formation. Two running backs line up side by side behind the quarterback. Another back, called the *flanker* or *wingback,* stands near the tight end.



The I-formation is an attacking formation in which the running backs line up directly behind the quarterback. The players often shift before the snap so that one back becomes a flanker.

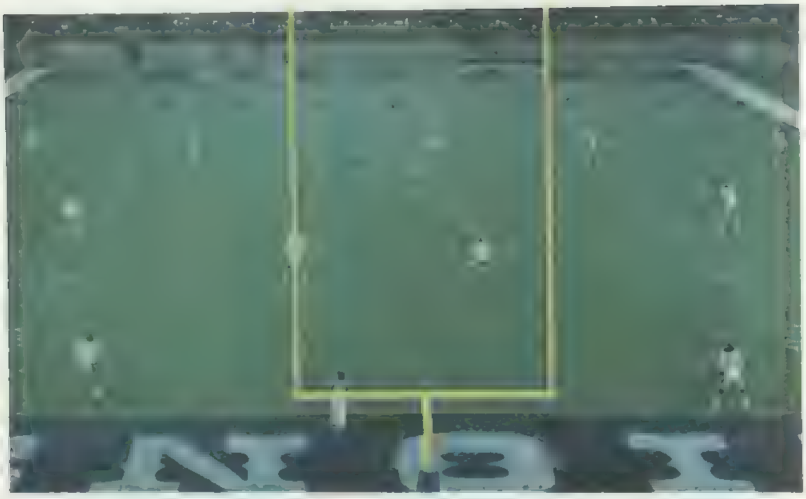


The three-four defence is often used when the defence expects a pass. It has only three linemen. The four linebackers and four defensive backs provide extra coverage of receivers.



The four-three defence is the basic defence in professional football. The four linemen, three linebackers, and four defensive backs can defend well against both passing and running plays.

Key to positions SE = Split End; LT = Left Tackle; LG = Left Guard; C = Centre; RG = Right Guard; RT = Right Tackle; TE = Tight End; QB = Quarterback; F = Flanker; HB = Halfback; FB = Fullback; E = End; MG = Middle Guard; T = Tackle, LB = Linebacker; CB = Cornerback, S = Safety



The kickoff begins each half. A team also kicks off after scoring a touchdown or a field goal. The receiving team, *foreground,* places two players near its goal line to run back the kick. The kicking team lines up in a row across the field. The kicker, *top centre,* kicks the ball from a tee.

Many defending teams favour *zone coverage* in the secondary, and others prefer *man-to-man coverage.* In zone coverage, each defending back is given responsibility for a certain area of the field. In man-to-man coverage, a defending back is assigned to cover a particular receiver.

The coaches. Every team has a coaching staff made up of a *head coach* and a number of *assistant coaches.* The head coach decides which players play which positions and, often, what plays are used during a game. In most cases, assistant coaches work with particular players.

How football is played

The playing time in NFL football games is 60 minutes. A game is divided into *halves.* Each half, in turn, consists of two periods called *quarters.* An intermission, called *half-time,* lasts about 20 minutes between halves. There are also 1-minute or 2-minute rest periods after the first and third quarters. At the end of each quarter, teams change ends.

The official time clock is stopped only (1) after an incomplete pass, (2) if a player is injured, (3) after a team scores, (4) if a ball carrier goes out of bounds, or (5) if a player on either team or an official calls a time out. Each team may call up to three two-minute time outs each half. During the final 2 minutes of a game, the clock is stopped after some plays while the ball is placed in position for the next play.

The kickoff starts each half of a football game. A team also kicks off after it scores a touchdown or a field goal. The team that kicks off to begin the game is decided by the toss of a coin at midfield. The visiting team calls "heads" or "tails." The team that wins the toss may (1) make the kickoff, (2) receive the kickoff, or (3) select the goal it wishes to defend. In most cases, teams choose to receive the opening kickoff to get the first chance at scoring. The team that loses the toss gets the choice of kicking, receiving, or defending either goal when the second half begins.

The kick off is made from the 35-yard line. Most kickers *place-kick* the ball. Before kicking the ball, they stand it at an angle on a tee.

The kicker's teammates stand in a line across the field until the ball is kicked. Generally, the receiving team places two fast runners near its goal line. The runner nearest the ball catches it and runs it back toward the other team's goal. The kick returner's teammates try to block the opposing players, who are running down the field to tackle him.

The line of scrimmage is an imaginary line that extends from the forward tip of the ball to both sidelines. Attacking and defending players must stay on their side of the line until the centre snap begins the play. If a player crosses the line of scrimmage before the snap, an official calls an *offside* penalty on that player's team.

A pitchout is a play in which the quarterback *pitches* (tosses) the ball underhand to a back who runs around end. In the play above, another back runs ahead of the ball carrier to block.

Tackling is the chief defensive skill. The tackler usually hits with his shoulders and wraps his arms around the ball carrier, *above*. He must hold tight so the runner cannot squirm away.

After a kickoff travels about 10 yards, it becomes a *free ball*—that is, either team may recover it. Normally the kicker tries to kick the ball as far down the field as possible. Occasionally, the kicker will kick the ball only a short distance to give his team a chance to recover the ball before the receiving team does. This manoeuvre is called an *onside kick*.

The ball is ruled *dead* if it is kicked beyond the end zone or if the kick returner catches it in the end zone and touches the ground with his knee. A *touchback* is then called, and the ball is put in play on the receiving team's 20-yard line. If the ball goes out of bounds before reaching the goal line without being touched, it must be kicked again.

The kick returner is ruled *down* if he goes out of bounds or if any part of his body except his feet or hands touches the ground. In the NFL, he must be downed by an opponent. If he slips and falls but is not touched by an opposing player, he may get up and advance the ball until he is tackled or goes out of bounds.

Advancing the ball. After the kick returner has been downed, the ball is placed at the point where the return ended. The attacking and defending teams then come on the field.

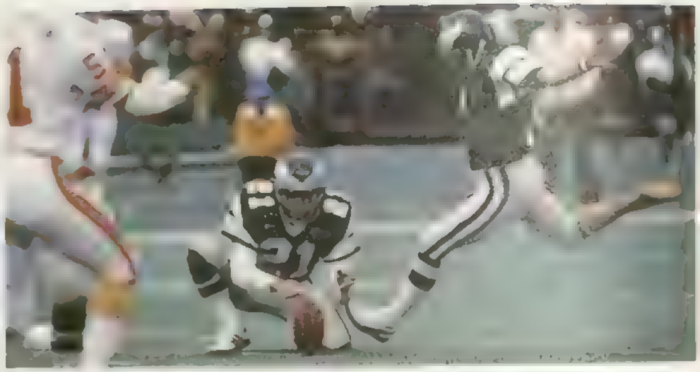
The attack has four plays, called *downs*, to advance the ball at least 10 yards by running or passing. If the attack gains this distance, it gets a *first down*. If the team fails to make a first down, it loses possession of the ball. Each time the team gets a first down, it receives another four downs to gain another 10 yards.

Before a play begins, each team gathers in a huddle behind its side of the line of scrimmage. In the attacking huddle, the quarterback names his team's next play, the formation to be used, and the number or colour he will call out to signal the centre to snap the ball. In the defending huddle, a formation is called that the team hopes will stop the attack.

After the teams have huddled, they line up facing each other along the line of scrimmage. The centre begins the play by snapping the ball to the quarterback. The quarterback then hands or *pitches* (tosses) the ball to a running back, runs with it himself, or throws a pass.

Passing combined with a good running attack produces a well-balanced attack. A good passer can concentrate on throwing the ball accurately even when he is about to be tackled, *above*.

A pass receiver makes a difficult catch, *above*, after manoeuvring away from the defence. A good receiver can catch the ball while running swiftly and hold onto it while being tackled.



Kicking consists of punting, *left,* and place kicking, *above.* For a punt, the centre snaps the ball back to the kicker, who drops it and kicks it before the ball hits the ground. For a place kick, the centre snaps the ball back to a kneeling holder. The holder places the ball on one end. Unlike most place kickers, the player above is kicking barefoot.

The attack directs running plays around either end, between the end and the tackle, between the tackle and the guard, or between the guard and the centre.

On a passing play, the passer is usually the quarterback. Occasionally, another back or even an end will throw the ball. The passer must throw the ball from behind the line of scrimmage. Only the ends and backs may catch a pass. The tackles, guards, and centre must stay behind the line of scrimmage until the ball is thrown. They may then run down-field and block for the pass receiver.

If a defending player catches a pass, it is called an *interception.* The defending player may return the ball toward the opponent's goal until he is downed or goes out of bounds. His team's attacking players then come on the field and try to score. The defence may also gain possession of the ball by recovering a fumble. A fumble occurs if an attacker drops the ball.

If the attacking team does not make a first down in three plays, it usually punts the ball on fourth down. A punt gives possession of the ball to the other team. If the attack tries to make a first down on fourth down and fails, the other team gets the ball where the play ends. Any attacker may punt. The kicker stands about 9 to 11 metres behind the centre, who snaps the ball to him for the punt. A long or well-aimed punt can force the opposing team to start its attack deep in its own side of the field.

Scoring. A team earns points by scoring (1) a touchdown, (2) a conversion, (3) a field goal, and (4) a safety.

Touchdown. A touchdown earns six points. The attack scores nearly all touchdowns. It does so by running the ball or catching a pass over the opposing team's goal line. Occasionally, the defence scores a touchdown through an interception or a fumble or by recovering a blocked punt in the end zone.

Conversion. Immediately after a touchdown, the scoring team tries for a conversion, also called the *extra point* or *point after touchdown.* Before a conversion attempt, the ball is placed on the 2-yard line. A kicker scores one point by place kicking the ball over the crossbar and between the goal posts. A successful conversion scores one point whether it is kicked, run, or passed.

Field goal. A field goal is worth three points. It is scored by place kicking the ball over the crossbar and between the goal posts. The kick may be made from anywhere on the field.

Safety. Only the defence can score a safety, which counts as two points. The defence earns a safety if it tackles the ball carrier in his own end zone, if the ball carrier steps out of the back or side of his end zone, or if a blocked punt goes out of the end zone.

The officials consist of a referee, an umpire, a head linesman, a field judge, a line judge and a side judge. They supervise the game and enforce the rules. Each official has particular duties, but any of the officials may call a rule violation.

Violations and penalties are called when players break the rules. In most cases, a violation occurs during a play, and the officials allow the play to be completed. The referee then explains the violation to the captain of the fouled team. The captain may accept the penalty to be imposed on the team that committed the foul, or he may refuse the penalty and accept the completed play. If he accepts the penalty, the down is usually replayed. If he accepts the play, the penalty is disregarded. A team is penalized for a violation with a loss of yardage and, in some cases, also the loss of a down. Common violations include (1) clipping, (2) holding, (3) offside, (4) interference, (5) delay of game, (6) roughing, and (7) illegal procedure.

Clipping is committed if an attacking player blocks a defender from behind, beyond the line of scrimmage. The penalty is 15 yards.

Holding is called against an attacker who uses his hands to block a defender. The penalty is 10 yards for the attack holding and 5 yards for the defence holding. The latter also includes an automatic first down for the attack.

Offside is called if a player crosses the line of scrimmage before the ball is snapped. The penalty is 5 yards.

Interference is ruled if the pass receiver or pass defender is blocked, tackled, or shoved while the ball is still in the air. In defensive interference, the attack gets the ball at the spot of the foul and receives a first down. In attacking interference, the attacking side is penalized 15 yards and a down.

Delay of game. The attacking team must put the ball into play within 30 seconds after the referee has signalled play to begin. The defence may be charged with a delay penalty if it kicks the ball out of bounds on a kickoff or if it deliberately slows down the game. The penalty for delay of game is 5 yards.

Roughing is a foul committed against a kicker or passer. The defence may not tackle or bump a kicker while he is in the act of punting or place kicking. The defence may tackle a passer only while he has the ball. The player may not be hit after he throws the pass. The penalty for roughing a kicker or passer is 15 yards and an automatic first down.

Illegal procedure is called if the attack does not have seven players on the line of scrimmage or if an attacker moves forward before the ball is snapped. Illegal procedure is also called if the attack or defence has more than 11 players on the field. The penalty is about 5 yards.

Football competition

Most organized football games in the United States are played by high school, college, and professional teams. More than 14,000 U.S. high schools, and more than 700 U.S. colleges and universities have football teams.

Professional competition is organized by the National Football League, which consists of 28 teams, each of which represents a city or region in the United States. The teams are divided into the American Football Conference and the National Football Conference, each of which has 14 teams. Each conference consists of three divisions—Eastern, Central, and Western. The National Football League title is decided in an annual game called the *Super Bowl.*

The history of American football

Beginnings. American football began to develop during the mid-1800's, when a game similar to Association football was played in the Eastern United States. The object of the game was simply to kick a round ball across the other team's goal line. The football teams sometimes consisted of 30 or more players.

As the soccerlike game became popular, stricter rules were adopted and schools began to organize teams.

The first game resembling present-day American football was played in 1874, when a team from McGill University in Montreal, Canada, visited Harvard University. The Canadian team wanted to play the English game of rugby, which permitted running with the ball and tackling. Harvard preferred to play its soccerlike game, in which players advanced the ball mainly by kicking. The teams agreed to play two games, the first under Harvard rules and the second under McGill rules. Harvard liked McGill's rugby game so much that the school introduced the sport to other Eastern colleges. Running and tackling soon became as important as kicking in the U.S. game.

Shortly after the Eastern colleges began to play rugby-style football, they started to change the way the game was played.

Changes in the game. By 1900, American football consisted mostly of running, blocking, and tackling. The blocking and tackling became increasingly violent, and many players suffered serious injuries. The uniforms provided little protection. Players did not even wear helmets. Rules were sought to eliminate some of the violence. One new rule, introduced in 1906, permitted a back to throw the ball forward to another back or to one of the ends. By the 1920's, most other basic rules had been adopted.

The rise of professional football. Professional football had little organization until 1920, when the American Professional Football Association was founded. In 1922, the organization was renamed the National Football League (NFL).

In its early days, professional football was far less popular than college football. Professional football began to gain popularity during the 1960's, when TV networks paid millions of dollars to televise games. In 1960, another professional league, the American Football League (AFL), was formed. In 1966, after six years of rivalry, the two leagues agreed to merge in 1970 into one league consisting of the American Football Conference and the National Football Conference.

American football today. During the 1970's and 1980's, TV continued to play a major role in the popularity of American football. The Super Bowl became the most popular annual televised sports event in the United States.

After the first two games of the 1982-1983 season, the NFL players went on strike. This was the first regular-season strike in NFL history. Play resumed eight weeks later. In 1989, the NFL announced it would sponsor a new professional international football league, to consist of teams in North America and Europe. Games were to be played in the spring, and competition was to begin in 1991.

In the 1980's, American football was introduced into Great Britain by a commercial television company. It proved to be very popular, although when played in Great Britain the game has slightly different rules from American NFL football.

Related articles in *World Book* include:

Camp, Walter
Football, Association
Heisman Memorial Trophy
Lombardi, Vince
Ohio (Places to visit)
Payton, Walter
Rugby football
Thorpe, Jim

Outline

I. The field and equipment
- A. The field
- B. The ball
- C. The uniform
- D. Protective equipment

II. The players and coaches
- A. The attacking team
- B. The defending team
- C. The coaches

III. How football is played
- A. The playing time
- B. The kickoff
- C. Advancing the ball
- D. Scoring
- E. The officials
- F. Violations and penalties

IV. Football competition

V. The history of football

Questions

When did American football begin to develop?
How does *zone coverage* differ from *man-to-man coverage*?
What are *hash marks*?
What is *clipping*? *Roughing*?
How does a team score a *safety*?
In what ways may the offensive team lose possession of the ball?

Football is the world's most popular sport. Action-packed goalmouth play makes it a thrilling game. Tens of thousands of spectators attend the big matches. In the incident above, defenders try in vain to keep the ball out of their goal in an English cup final.

Association football

Football, Association, is the world's most popular sport. It is the national sport of most European and Latin-American countries, and of many other nations. It is known simply as *football* in most English-speaking countries. It is also often called by its popular name, *soccer.*

Millions of people in more than 160 countries play football. The game's most famous international competition, the World Cup, is held every four years. The finals are watched by a worldwide television audience of hundreds of millions.

Two teams of 11 players take part in a football match. They attempt to send the round ball into their opponents' goal. A successful attempt is called *scoring a goal.* The team scoring the most goals in the two 45-minute periods wins the game. Players use their feet, head, or any other part of their body except hands and arms to propel or control the ball. One player from each side, the goalkeeper, may handle the ball, but only in a restricted area around the goal. There is considerable physical contact as opposing players contest possession of the ball.

Football as it is played today began in England in the mid-1800's. The game grew rapidly in England and Scotland, and soon spread to other parts of the world. The governing body for world football, the Fédération Internationale de Football Association (FIFA) was established in 1904. FIFA staged the first Olympic football competition in 1908, and the first World Cup in 1930.

At the highest level, football is a professional game. It is played mainly by boys and men. But it is becoming increasingly popular with female players, especially in Scandinavia and some other European countries.

Field and equipment

Football rules lay down dimensions for the field of play, the goals, and the ball. These may be modified for players under the age of 16. The size, weight, and material of the ball may also be modified for women players.

The football field, or pitch, is rectangular and may vary in overall size. The field is marked out by lines not more than 12 centimetres wide. At each corner is a flag, on a post not less than 1.5 metres high with a nonpointed top. Flagposts may also be placed opposite the halfway line on each side of the field, at least 1 metre from the touch lines.

The goals stand on the centre of each goal line. They consist of two upright posts joined at the top by a horizontal crossbar. The posts must be white, and are made of wood, metal, or other approved material. The inside measurements of the goal are 7.32 metres wide by 2.44

metres high. The widths and depths of the posts and crossbar must not exceed 12 centimetres. In section, the posts and crossbar must be square, rectangular, round, half-round, or elliptical. Nets are attached to the posts, and crossbar, and fixed to the ground behind the goal.

The ball is spherical, with an outer casing of leather or other approved material. It must have a circumference of 68 to 71 centimetres, and must weigh from 396 to 453 grams at the start of the match. The pressure inside may be from 0.6 to 1.1 atmosphere (600 g/cm² to 1100 g/cm²).

Players' equipment consists of a jersey or shirt, shorts, socks, shinguards, and footwear. All of these items are compulsory. The colour of the goalkeeper's jersey must be different from the shirts of players of either side, and from the referee.

A player must not wear anything likely to be dangerous to another player, such as sharp studs or a plaster cast. In international competition, the referee inspects the players' equipment before the game to ensure that it conforms to the rules. The rules of any competition may include a similar provision.

Rules

Football is played 11-a-side with a maximum of two substitutions. Depending on the rules of the competition, the substitutes may be chosen from a pool of not more than five nominated players. A player whose part in the game has been taken by a substitute may not return to the field.

The duration of the game is 90 minutes, split into two halves, with an interval of at least 5 minutes. The referee must add time lost for stoppages at the end of each half. Stoppages include substitutions, injuries, and deliberate time-wasting. At some levels of the game, including under-16 and women's football, shorter periods of play may be agreed. In some competitions, two extra periods of 15 minutes each may be played at the end of 90 minutes, in an attempt to break a tie.

The ball is in play at all times, unless the referee stops the game or judges the ball to have completely crossed the goal line or touch line. For a goal to be scored, the ball must completely cross the goal line between the posts. The side scoring the greater number of goals wins the game. If the two sides have an equal number of goals at the end of the game, the result is a draw.

Starting play. The team captain winning the toss may choose which goal to defend or may decide to *kick off* (start the game). At the start of the game, all the players must be in their own half of the field. The player kicking off must play the ball into the opposing half at least the distance of its own circumference. The player kicking off may not play the ball again until it has been touched by another player. No opposing player may be within 9.15 metres of the ball, as determined by the centre circle, until it is in play.

The game is restarted in the same way after a goal has been scored, by the team against which it was scored. At the start of the second half, the game is restarted by the team that did not kick off at the start. The teams change ends at half-time.

The officials. A single referee controls the game, with the assistance of two linesmen. The *referee* patrols the field diagonally, and must be fit enough to keep up

The football pitch The field of play is rectangular. Its size may vary considerably, but for international matches must be 100-110 metres long by 64-75 metres wide.

The referee indicates a caution by displaying a yellow card. A player is sent off when shown a red card.

with the fast-moving play. The referee uses a whistle to start and stop play, and hand signals to indicate decisions. The referee holds up coloured cards to show punishments for players' offences. A yellow card indicates an official caution, or *booking;* a red card indicates that the offending player is *sent off* and must leave the field.

The referee punishes infringements of the rules by awarding a free kick to the other side. In the case of *foul play,* he or she has to decide whether the *foul* (a violation of the rules) was intentional. The referee must also refrain from stopping play for a foul in cases where he or she is satisfied that, by stopping play, the offending team would gain an advantage. However, the referee cannot allow play to continue, and then blow the whistle for a foul if the offending team is seen to benefit from the infringement. The referee must make a decision immediately.

In addition to enforcing the rules, the referee keeps a record of the game's scores and acts as timekeeper.

The *linesmen* patrol the touch lines. The linesmen's chief duties are to flag when the ball goes out of play. The linesman indicates which team is entitled to put the ball back into play, and also informs the referee when either team wishes to substitute a player. Linesmen also help the referee to control the game, flagging to draw attention to any breach of the rules the referee might have missed, or when they judge a player to be *offside* (see **Offside,** below).

Restarts. The game is restarted after the ball has gone out of play, or the referee has stopped play, by a kick, a throw, or a dropped ball. A kick is taken when the ball goes out over the goal line. A throw is taken when the ball goes out over the touch line. The referee also awards a kick against a side for a foul or for misconduct. The player restarting play with a kick or throw may not play the ball again until it has been touched by another player. After a stoppage for some other reason, such as the urgent treatment of an injured player, the referee drops the ball into play between two opposing players.

Free kicks are awarded after an infringement by one team. Free kicks may be direct or indirect, according to the infringement. A player can score a goal from a *direct* free kick, but an *indirect* free kick must touch, or be touched by, another player before a goal can be scored. A free kick must be taken from the spot where the offence took place. When a player takes a free kick, no opponent may be within 9.15 metres of the ball.

A penalty kick is a direct free kick awarded for an offence, such as a deliberate foul or handling of the ball, committed in a player's own penalty area. A player from the other team takes a free kick at goal from the penalty spot (see field of play diagram). All other players, except the opposing goalkeeper, must be at least 9.15 metres from the penalty spot, and outside the penalty area. The goalkeeper must stand on the goal line, and must not move his or her feet until the kick is taken.

A corner kick is awarded to the attacking team when the ball goes out of play over the goal line, and was last touched by a member of the defending team. The kick must be taken from within the quarter-circle at the nearest corner flag post, and no opposing player may be within 9.15 metres of the ball. A goal may be scored directly from a corner kick.

A goal kick is awarded to the defending team when the ball goes out of play over the goal line, and was last touched by a member of the attacking team. The kick is taken from within the goal area on the side nearer where the ball went out of play. No opposing player may be inside the penalty area when a goal kick is taken. The ball must travel outside the penalty area before it is in play again.

Throw-ins are awarded when the ball goes out of play over the touch line. A player from the team opposing that of the player who last touched the ball takes the throw from the point where it crossed the line. The thrower must use both hands to deliver the ball from behind and over his head. The player must face the field of play, and part of each foot must be grounded on or behind the touch line. If the ball is improperly thrown in or taken from the wrong place, the throw goes to the opposing side. A player cannot score a goal directly from a throw-in.

Dropped ball. When the referee has to stop play temporarily, other than to award a kick or throw, the game is restarted by dropping the ball between two players from opposing sides. The referee drops the ball at the spot where it was when play was stopped. The players may not play the ball until it touches the ground.

Fouls and misconduct. The referee punishes offences by awarding a free kick or *penalty* (free shot at goal) to the other side. For serious offences, the referee may also caution or send off the offending player.

A player must not kick, trip, push, hold, strike, jump at, or spit at an opponent. A player may charge an opponent fairly shoulder to shoulder, but not in a violent or dangerous manner or from behind (unless being obstructed). Apart from a goalkeeper in his or her own penalty area, a player must not touch the ball with the hands or arms. All of these offences are punishable by a direct free kick to the other side, or by a penalty if they take place in the offender's own penalty area.

An indirect free kick is awarded against a player guilty of dangerous play, obstruction, charging an opponent when the ball is not within playing distance, or charging the goalkeeper unfairly, and for certain other offences. An indirect free kick may be awarded against a goalkeeper for deliberate time-wasting, or for breaking the "four-step" rule. According to this rule, once the goalkeeper has the ball in his or her hands, he or she may not take more than four steps before releasing it into play again. Having released it, he or she may not play it with the hands again until it has been touched by a team-mate outside the penalty area or by an opponent. Offside is also punishable by an indirect free kick.

The referee *cautions* (shows a yellow card to) a player for persistent infringement of the laws, ungentlemanly conduct, dissent, or for entering or leaving the field without the referee's permission. For a repeated or more serious offence, a player may be sent off the field. The referee sends a player off for violent conduct, spitting at an opponent, serious foul play, or the use of abusive language. A player *sent off* (shown the red card) may not return to the game, nor may a substitute be sent on in his or her place. A player committing a second cautionable offence is automatically sent off.

Offside. A player is in an offside position if, at the moment the ball is played by a team-mate, the player is in the opponent's half and nearer to the goal line than the ball, unless at least two opponents are level with the player or nearer to the goal line. A player is penalized for being offside only if he or she plays the ball, or if the referee judges that the player is interfering with play or an opponent, or is seeking to gain an advantage by being in that position.

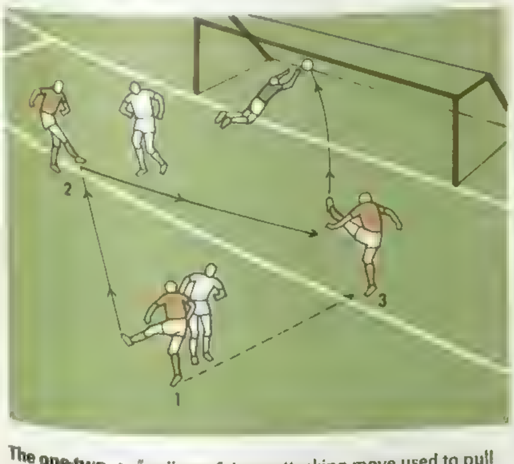
Team tactics

Team tactics are often described by using numbers to relate to the players (excluding the goalkeeper). For example, a *4-3-3 formation* means that a team is playing with four defenders, three midfield players, and three attackers, or forwards.

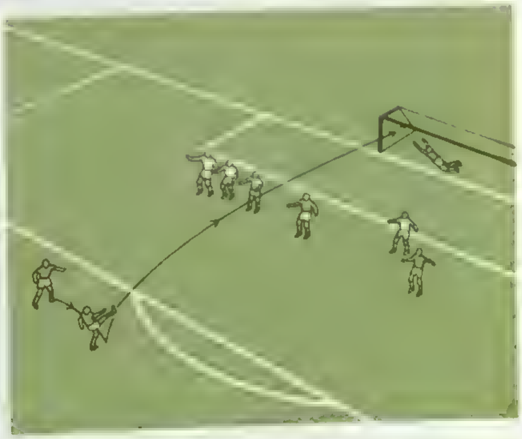
Defence. The chief role of *defenders* is to break up opposing attacks by intercepting opponents' passes, or by tackling opponents to win the ball from them. There are two basic defensive systems, zonal marking and "man-for-man" marking. In *zonal marking,* each defender is responsible for one *zone,* or strip of the pitch. (These zones are not marked.) Each defender *marks* (stays close to) any attacker who moves into this zone. Zonal marking is usually operated with four defenders, two *full-backs* and two *central defenders.* In *"man-for-man" marking,* each defender is responsible for marking a particular opponent, and following wherever he goes. Teams playing this system usually have a *sweeper,* a player who does not mark any one opponent, but instead covers the other defenders from behind whenever an opposing forward threatens to break through. The "man-for-man" system can be used with four defenders plus a sweeper so that, if there are only two attackers to mark, the spare defenders can attack along the touch lines.

Midfield. The *midfield* is the link between defence and attack. Most teams operate with three or four midfield players. Midfielders require considerable stamina, as they are expected to play a part in both defence and attack.

The midfield is a busy area of play, and there are several types of midfielders. The chief role of the *anchor-man* is to win the ball. The *midfield general,* or *playmaker,* tries to dictate the pattern of play and set up attacks. *Through-runners* make runs at goal from deep positions, aiming to arrive unmarked to meet a long pass from a team-mate. Some teams operate with one of each of these types of midfielders. Many midfielders perform more than one role. Another type of midfielder is the *withdrawn winger,* who attacks along the wings, near the touch line, but also tackles back in defence.



The one-two, or "wall pass", is an attacking move used to pull the opposing defence out of position and create a goal chance. Player 1 passes to player 2, and moves past the opponent into position 3 to take the quick return pass.



Free kicks just outside the opponents' penalty area offer good goalscoring opportunities. Opposing players may line up in a "wall" to cover one side of the goal while the goalkeeper covers the rest of it.

Football terms

Advantage. A referee may choose to ignore a foul, judging that to stop play would give the offending side an advantage.
Bend is to kick the ball so that it swerves in flight.
Caution, or **booking,** is an official warning by the referee to a player, accompanied by the display of a yellow card.
Centre, or **cross,** means to play the ball to a fellow attacker from the wing into the goalmouth.
Charge is the legal shoulder-to-shoulder contact made on a player with the ball.
Chip is a lofted pass or shot made by kicking the ball from the ground over an opponent.
Close down means to approach an opponent who has the ball in such a way that the opponent finds it hard to make good use of the ball.
Cover means either to support a team-mate who is under pressure or to mark an opponent.
Dead ball occurs when the ball goes out of play or the referee stops the game.
Dissent, an offence, means showing disagreement with the referee's decision.
Dribbling means running with the ball under close control at the feet, nudging it along.
Goalmouth is an undefined area close to the goal.
Lay off means to take a pass, usually facing the direction of play, and transfer it back or sideways to a team-mate.
Marking means guarding an opponent.
Obstruction is an offence that occurs when a player deliberately gets in the way of an opponent without attempting to play the ball.
One-two is a quick exchange of passes between two players, usually made to get past an opponent.
Overlapping is a move in which a defender, usually a fullback, comes into the attack along the wing.
Restart is any method used to start the game after a stoppage.
Running off the ball means moving into positions to support team-mates or distract opponents.
Screening is keeping body and feet in the way of an opponent while playing the ball.
Wall is a defensive barrier formed by two or more players, usually to block shots at free kicks.

Attack. The chief attacking players are *central striker* and *winger.* Teams may operate with two of each. There is usually at least one central striker. Some teams play without wingers. For example, in a 4-4-2 formation, there might be just two central strikers, with wing positions taken up by other players making runs to, or along, the touch lines.

The main function of some strikers is to act as *target* players. Such a player should be available to accept passes from midfield or defence, and to *lay the ball off* (pass back or sideways) to fellow forwards or to midfielders running forward. In most teams, one striker is the chief goalscorer, always looking to take up good scoring positions and ready to make an attempt at goal. A winger's chief job is to pull defenders out of position by taking the ball to the goal line, and to set up goal chances for team-mates by sending the ball across into the goalmouth. Wingers should also be prepared to run toward the penalty area to attempt to score a goal.

Team play. An important part of team play is *off-the-ball running*—that is, players without the ball taking up positions to give a team-mate more options for making passes, or to draw defenders out of position. *Set-pieces* are tactical manoeuvres involving two or more players, especially at restarts, or *dead-ball* situations, such as free kicks, corners, and throw-ins. Teams practise set-piece plays, and players often use signals to let team-mates know which particular play they intend to use.

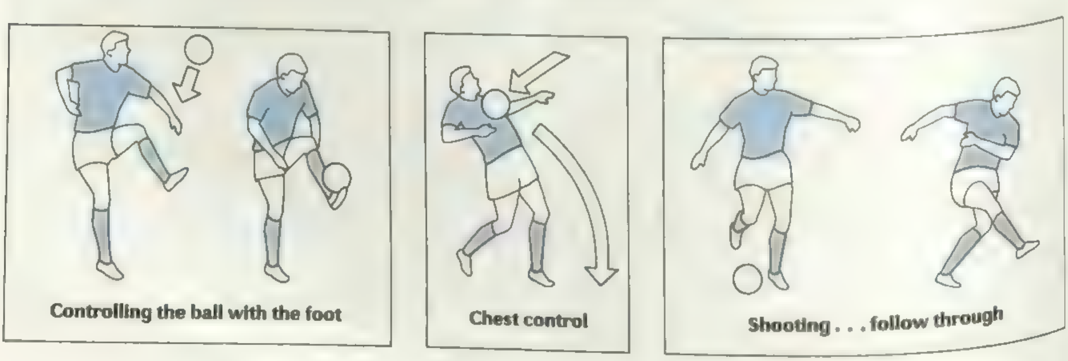
Skills

Playing the ball with the foot involves a variety of skills—controlling the ball, passing, shooting, dribbling, and tackling. Heading is a skill unique to association football. Goalkeeping calls for special techniques not required by the outfield players.

Control. Players can control the ball with any part of their body except hands and arms. A player receiving the ball usually has to *take the pace off it* (slow it down) by skilful movement of foot, thigh, or chest, which brings the ball under control at his or her feet. He or she then has to push the ball in the right direction with just enough force so as not to lose control of it.

Passing is the most important team skill. Players pass the ball in many ways. They make long and short passes, direct, swerved, and chipped passes. They pass the ball with their feet, their head, and their chest. The object is to pass the ball to a team-mate who is in a better position to use the ball, to build up an attack, or perhaps to shoot. Just as important as passing is the support players give to a team-mate who has the ball. When several players make themselves available to receive a pass, they give the player in possession more options.

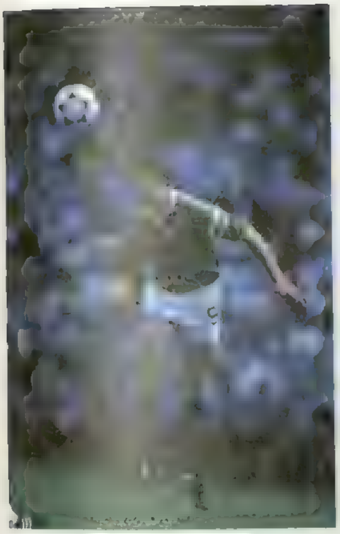
Football skills Footballers must control the ball without using their hands or arms. Players use their feet, thighs, chest, head, and other parts of their body to control the ball and to move it. When shooting for goal, players place their nonkicking foot by the side of the ball.



Controlling the ball with the foot

Chest control

Shooting . . . follow through



Heading is a skill unique to football. For a power header, the player meets the ball at the top of the jump. Good timing is important, and contact should be made with the forehead.

Dribbling calls for balance and close control. The player twists and turns to deceive opponents, while keeping the ball close to the feet. The legs and body are used to "screen" the ball.

Goalkeeping needs agility, judgment, and good ball-handling ability. It takes courage to dive at an opponent's feet or to punch the ball away under pressure, *above.*

Accuracy is important when making a pass. So too are *weighting* (the strength of a pass) and timing. Played too hard, a pass might be difficult for the receiver to control. If the pass is not strong enough, it may be intercepted by an opponent. A quick, "first-time" pass can open up a defence before the defenders have time to position themselves. But a pass may have to be delayed to allow a team-mate to move into a better position.

A player uses different parts of the foot to pass the ball. Short passes may be made with any part. Passing with the inside of the foot, using a sideways movement, is the most reliable and accurate method for making a straight pass over short distances. But there is often a need to *bend* (swerve) the ball, in order to avoid an opponent or to curl the ball into the path of a teammate. Players bend the ball by striking it with the side of the foot.

Using the outside of the foot bends the ball away from the player; using the inside of the foot bends it across the player's body. To *chip* the ball, in order to loft it over the opposition, a player's foot makes contact with the underside of the ball and the ground at the same time, while the player is leaning slightly back. This technique is often used when *crossing* (centring) the ball from the wing to the goalmouth. When crossing, a player can bend the ball out of reach of the goalkeeper by using the inside of the foot.

Shooting (kicking toward the goal). Players kick with the instep to strike a ball powerfully and accurately. The nonkicking foot should be placed alongside the ball, the head kept down, and the body well over the ball. After the ball is kicked, the kicking foot should follow through. A player can impart swerve to a shot by using the same techniques as in passing. Not all goals are scored by powerful kicks or shots. Many goals are scored by deflections, short-range "prod-ins", or chips over the goalkeeper. Players normally use the instep for *volleying* the ball—that is, striking it while it is in the air.

Heading. With good timing and the correct use of the neck muscles, a player can head the ball accurately and powerfully. Contact should be made with the forehead. The neck muscles are used to "punch" the ball.

When defending, players try to head the ball up and away from danger, preferably to a team-mate. In attack, a player heads powerfully for goal, often twisting the head round to meet a cross and deflect the ball at an angle towards the goal. Downward headers are the most difficult for goalkeepers to stop.

Allowing the ball to hit directly any other part of the head apart from the forehead can be painful and even dangerous. An exception is when a player glances the ball off the top of his head. If this is done while standing at the near post when a corner kick is taken, the defence finds such a "flick-on" difficult to deal with. A player heading the ball usually aims to meet it at the top of the jump, especially when competing with opponents for it.

Dribbling is one of the most exciting features of football. Players run with the ball at their feet, nudging it along. They use speed, skill, and trickery to keep possession and to avoid the tackles of their opponents. Running at opponents with the ball can break even a well-organized defence.

Players use all kinds of deceptive movements to confuse and unbalance opponents. They may *feint* (pretend to go one way but go another), *dummy* (pretend to kick the ball but not do so), or use swivelling movements of hips or shoulders to send defenders the wrong way. Good dribbling calls for balance, acceleration, body swerve, and the ability to use each side of either foot to control the ball. A player must also know when to release the ball, to shoot for goal, or pass to a team-mate who is in a better position.

Tackling is an important aspect of the wider skill of *ball-winning.* Gaining possession calls for good positional sense, timing, and the ability to "read the game". Good defenders will often win the ball by intercepting a pass or *closing down* an opponent so that he or she loses control. Physical tackling with the foot is often a last resort, because missing the ball may leave a player's defence open or foul an opponent.

The two basic tackles are the block tackle and the sliding tackle. To make a *block tackle,* a player approaches the player in possession square on and goes for the ball with the inside of his or her foot. Keeping the rest of that leg and the bodyweight behind the ball, the player tries to wrench or hook it away cleanly to gain possession of the ball. The *sliding tackle* is usually made from the side, typically when an opponent is close to the touch line or goal line. The aim is to push the ball to safety—in touch or for a corner—as the tackler finishes up on the ground and is rarely in a position to take possession. In making the tackle, the player slides the foot along the ground, while the knee of the nontackling foot approaches the ground.

Goalkeeping calls for sharp reflexes, agility, speed off the mark, good ball-handling ability, and fine judgment. The ability to read a situation is essential for a keeper who must decide whether to stay on the goal line as play approaches, or come out to meet a high cross or a through ball.

Goalkeepers must be fairly tall to cover the goal. They aim to make the target as small as possible for an attacker trying to shoot. Courage and confidence are also important. Keepers are exposed to physical contact when they stretch high to catch a ball or dive at the feet of an onrushing attacker.

Keepers must also develop a good understanding with their team-mates. They should be master of their penalty area, calling to claim the ball when necessary. When keepers gain possession of the ball, they should be able to make quick, accurate throws and long kicks to set up attacks.

Other football skills include screening the ball and turning with the ball. *Screening* is a skill that footballers should develop and use naturally in their play, especially when dribbling or controlling the ball. It involves keeping the body between an opponent and the ball, to make it difficult for the opponent to make a fair tackle.

Turning is a skill used chiefly by forwards with their back to goal. An attacking player takes a pass and turns at the same time to deceive his marker, and gain valuable space.

Leagues and cups

Football is organized in league and cup competitions. Teams also play so-called "friendly matches."

In *league football,* the teams in the *league* (group) usually play each other twice—at *home* (their own ground) and *away* (their opponents' ground). In most leagues, a win is worth two points, a draw one, and a defeat none. Some leagues award three points for a win or give bonus points for goals scored. When all the teams have played each other, the champion team is the one with the most points. Teams equal on points are separated by *goal difference* (the difference between goals scored by a team and goals scored against them).

League competition is the backbone of football. Players from Arsenal and Chelsea league clubs, *above,* battle for the ball in an English First Division match.

When goal differences are equal, the team scoring more goals takes precedence.

In most major footballing countries, leagues are structured in several divisions. There is usually a system of *promotion* (upward movement) and *relegation* (downward movement) between the divisions for the top and bottom teams, respectively.

Small leagues are often used to eliminate teams in major tournaments, such as the qualifying stages and the finals of the World Cup. Again, goal difference is used to separate teams with equal points. If two teams cannot be separated, and there is no time in the schedule for a play-off, they may have to draw lots.

Cup competitions are organized on a knock-out basis. The cup *draw* (lottery) determines whether a team plays at home or away, and who the opponents will be. If the match is drawn, it is replayed on the other side's ground. If the sides are still equal at the end of this second game, extra time (15 minutes each way) may be played, and further replays may have to take place.

A round of some knock-out competitions involves a home and away game, each called a *leg.* The winner of each *tie* (a match in an eliminating competition) is then determined on the aggregate, or combined total, score over the two legs. If the teams are level after the 90 min-

utes' regular play in the second leg, extra time may be played. If the teams are still level after extra time, the tie may be decided on the *away goals rule*. By this rule, all goals scored by the team playing away from home count double. Otherwise, the teams might have to break the tie by taking a series of penalties.

In *penalty deciders*, also called *penalty shoot-outs*, each team has five penalties, taken alternately, no player taking more than one shot. If the penalty score is equal after the series of five penalty kicks by each side, further penalties are taken by different players until one side has a goal lead after both sides have taken an equal number of kicks.

The world game

The world governing body for football is the Fédération Internationale de Football Association (FIFA), with headquarters in Zurich, Switzerland. FIFA organizes the World Cup and other international competitions, such as world youth and junior championships. FIFA recognizes six continental groupings, which organize the game in their regions.

The World Cup is held every four years. Countries qualify for the finals over the previous two years through elimination groups in their continental zones. Twenty-four nations contest the finals. The titleholders and the host country qualify automatically. Of the other 22 places, 12 are currently allocated to Europe, with 3 each to South America and Africa, 2 to Asia, and 1 to North and Central America. Oceania's champions have to play off with the runners-up from the North and Central American zone and a South American country for the last place in the finals. The World Cup finals take place over a period of about a month at several venues in the host country. The qualifying nations are divided into six groups of four, from which eight teams are eliminated. From the last 16, or eighth-finals, the competition becomes a straight knock-out contest.

Brazil are the only country to have appeared in every World Cup finals competition. They won their fourth trophy in 1994.

Individual players who have starred in the World Cup include Brazil's Pelé, who scored 12 goals in four com-

World Cup final matches

1930	Uruguay 4 Argentina 2 (Montevideo)
1934	Italy 2 Czechoslovakia 1 (Rome)
1938	Italy 4 Hungary 2 (Paris)
1950	Uruguay 2 Brazil 1 (Rio de Janeiro)*
1954	West Germany 3 Hungary 2 (Berne)
1958	Brazil 5 Sweden 2 (Stockholm)
1962	Brazil 3 Czechoslovakia 1 (Santiago)
1966	England 4 West Germany 2 (London)
1970	Brazil 4 Italy 1 (Mexico City)
1974	West Germany 2 Netherlands 1 (Munich)
1978	Argentina 3 Netherlands 1 (Buenos Aires)
1982	Italy 3 West Germany 1 (Madrid)
1986	Argentina 3 West Germany 2 (Mexico City)
1990	West Germany 1 Argentina 0 (Rome)
1994	Brazil 0 Italy 0 (Pasadena)†

*Deciding match of final pool. †Brazil won 3-2 on penalty kicks

The World Cup is held every four years. Here, England (white shirts) and Cameroon contest a quarter-final match in the 1990 competition in Italy. Cameroon were the first African team to reach this stage of the finals. They lost 3-2 to England, but confirmed the emergence of Africa as a new power in international football.

petitions from 1958 to 1970, and West Germany's Uwe Seeler, who scored 9 over the same period. The record for the most goals in World Cup competition was set by Gerd Müller of West Germany, with 14 in 1970 and 1974. Just Fontaine of France set the record for a single competition, with 13 in 1958. The only player to score three goals in a World Cup final was Geoff Hurst, for England, in 1966.

Europe. The governing body for Europe is the Union of European Football Associations (UEFA). The European Championships are held every four years. More than 30 countries take part, eight qualifying for the finals. UEFA also organizes under-21 and youth competitions, and three major club competitions. The club competitions, which take place annually, are the European Cup, for champion clubs; the European Cup-Winners Cup, for national cup holders; and the UEFA Cup for other leading teams. They are run on a knock-out basis with home and away legs in each round except the finals of the European Cup and the Cup-Winners Cup.

The four United Kingdom countries—England, Scotland, Wales, and Northern Ireland—have their own Football Associations and compete separately at both country and club level.

South America has fewer footballing nations than Europe, but has won equal honours in international competition over the years owing mainly to the strength of Brazil, Argentina, and Uruguay. Football in South America is run by the Confederación Sudamericana de Fútbol (CONMEBOL). The chief competitions are the South American Championship for countries, and the Copa de los Libertadores for clubs.

Africa is the emerging continent in world football. The game there is run by the Confédération Africaine de Football (CAF). Twelve countries take part in the African Nations Cup, held once every four years. There are also international club championships. In international competitions African teams have produced encouraging performances against countries from the traditional strongholds of the game. The game is South Africa's most popular sport. In the early 1990's, the country's isolation from international sport ended. South Africa formed a national team and began competing against other countries.

North and Central America. Mexico, twice World Cup hosts, have dominated this group, which includes the Caribbean countries. The governing body is the Confederación Norte-Centro-Americana y del Caribe de Fútbol (CONCACAF). In the United States, despite the traditional popularity of American football and several false starts at professional level, soccer has grown in popularity in the schools. The United States team qualified for the 1990 World Cup finals, and the United States hosted the 1994 World Cup finals.

Asia. Football is a major sport in the Asian Games, held every four years. The Asian Football Confederation (AFC) also stages the four-yearly Asian Football Championships. The game is particularly popular in the Arab states and in Southeast Asia, China, and Japan.

Oceania. The Oceania Football Confederation (OFC) is the smallest continental association, and is dominated by Australia and New Zealand. It has included countries such as Israel and Taiwan in its World Cup qualifying group, for political reasons. In Australia, soccer has to compete with the rugby codes and Australian Rules football, but several leagues flourish, supported largely by immigrant communities. Australia (1974), and New Zealand (1982), have played in World Cup finals.

History

Historians believe that about 2,000 years ago the Chinese played a game that involved kicking a ball. The Ancient Romans are said to have encouraged a kind of football as part of military training. This game was probably introduced into the British Isles, either by the Romans or much later by the Normans.

There is a historical account of a football game played near London on Shrove Tuesday in 1175. Shrove Tuesday games became notorious as "mob football", in which hundreds of youths chased a ball through the streets, with little regard for people or property. This led to the banning of football by Edward II in 1314.

Later kings resented the game because it interfered with archery practice. But football survived and had become popular all over England by the early 1800's.

Unifying the rules. Football clubs began to be formed in the 1820's. Several kinds of football developed, particularly in the English independent schools.

"Goal!" Ireland's Niall Quinn celebrates after scoring against the Netherlands in the 1990 World Cup. The Irish held the Dutch to a 1-1 draw in this group match.

Australia (yellow shirts) played off with Scotland for a place in the 1986 World Cup finals. Australia lost 2-0 in Scotland and drew 0-0 at home.

Football was played in English independent schools in the mid-1800's. It was in these upper-class schools and the universities that the rules of football were first drawn up.

When students went to university, they needed a unified set of rules. A standard code was drawn up at Cambridge University in 1846, and revised in 1862 as *The Simplest Game,* with 10 rules. A year later, representatives of English clubs got together to form the Football Association (FA).

Clubs and competitions. In 1871, the FA Cup was introduced, the first competition of its kind in the world. In 1872, Scotland played England at Glasgow in the first international match. The first professional footballers were Scots enticed to play for reward by clubs in Lancashire, in northern England. This had the effect of transferring the stronghold of the game from the amateur clubs in the south to the north of England. In 1885, the FA legalized professionalism. Three years later, 12 English clubs formed the Football League. The rest of Europe soon followed the United Kingdom's (UK) lead in establishing league and cup competitions. Football also flourished in South America where, as early as 1867, a group of Englishmen founded the Buenos Aires Football Club in Argentina.

Governing bodies. FIFA was established in 1904 by seven European nations, although England did not join until 1906. Scotland, Wales, and Northern Ireland joined several years later. The UK countries withdrew from FIFA twice in the 1920's, the second time staying out until 1946. None of them competed in the World Cup until England took part in 1950.

However, the UK continued to play a leading role in the rule-making body, the International Football Association Board (IFAB). The four UK countries had founded IFAB in 1886, and FIFA members were admitted to the Board in 1913. IFAB is still the rulemaking body, with four voting members from FIFA and one each from the four UK Football Associations. A three-quarters majority is needed to make changes in the rules.

The modern game. No major changes have been made in the rules of football since the 1920's. However, the speed and tactics of the game have developed considerably due to improved equipment and training. Television has brought football to a much wider audience, and sponsorship has pumped a great deal of money into the professional game. Top footballers are among the highest-paid sports stars, and may be transferred between clubs for millions of pounds sterling.

Football hooliganism (violence among spectators) became a serious problem in the late 1960's. It began in England, with rival gangs of football followers fighting, destroying property, and generally creating havoc both inside and outside football stadiums. This so-called "English disease" spread to other European countries, and huge police operations became necessary to contain the rival gangs.

In 1985, the Heysel Stadium in Brussels was the venue for the European Cup final between English champions, Liverpool, and Italian champions, Juventus. The uncontrolled rampaging of Liverpool fans, together with faulty terracing, led to the deaths of 39 spectators, mostly Italians. This incident, together with further crowd tragedies in England, resulted in government action designed to improve safety at grounds. FIFA has also brought in legislation to encourage conversion of grounds to all-seater stadiums.

In 1991, the United States won the first FIFA-sponsored women's world football championship. In England, a new FA Premier League started its first season in 1992. The league was basically the same as the old First Division of the Football League. The United States hosted the 1994 World Cup finals. Brazil won the Cup for a record fourth time.

Outline

I. **Field and equipment**
- A. The football field
- B. The goals
- C. The ball
- D. Players' equipment

II. **Rules**
- A. Starting play
- B. The officials
- C. Restarts
- D. Fouls and misconduct
- E. Offside

III. **Team tactics**
- A. Defence
- B. Midfield
- C. Attack
- D. Team play

IV. **Skills**
- A. Control
- B. Passing
- C. Shooting
- D. Heading
- E. Dribbling
- F. Tackling
- G. Goalkeeping
- H. Other football skills

V. Leagues and cups
VI. The world game
- A. The World Cup
- B. Europe
- C. South America
- D. Africa
- E. North and Central America
- F. Asia
- G. Oceania

VII. History

Questions

How is a football game restarted if the ball goes out of play?
What is the World Cup?
What do the numbers refer to in a tactical formation such as 4-3-3?
What organization governs football competition around the world?
When does the referee award a *penalty kick?*
What is a *sweeper?*
How many substitutions can a team make under international football rules?
What are *dribbling; tackling?*
What organization governs the rules of football?
Which part of the foot should be used for shooting?

Football, Australian Rules. See **Australian Rules football.**

Football, Gaelic. See **Gaelic games.**

Football pools are a popular form of gambling in the United Kingdom. Millions of people take part in football pools. They *stake* (bet with) small amounts of money and try to forecast the results of association football matches. Many of these people listen anxiously to match results broadcast each Saturday during the football season. They hope that they have made an accurate forecast and won a prize. On days when a large number of games are prevented from being played because of bad weather, a specially appointed group of people called a *pools panel* decides what the results would have been if the matches had been held. Pools prizes are then awarded on the basis of the panel's decisions.

The largest football pools are run by companies, to make profits for their owners. Littlewoods and Vernons are the largest companies and both have their offices in Liverpool, England. These large football pools attract much stake money because they offer large prizes. Many smaller pools are run by charitable organizations or by individual football clubs. These pools usually offer small prizes.

The first football pools company was started in the 1920's. Football pools pay the government a duty of 40 per cent of the money staked with them. Pools companies also spend millions of pounds each year supporting the game of football.

Footnote is a note printed in small type at the bottom of a page. It is used to give information that is too long or too detailed to be included in the original statement. Footnotes sometimes explain a word or idea that might easily be misunderstood, but more often they merely cite the source or authority for what the author says. Footnotes help to keep sentences short and free of excess facts. For example, a student writing a composition about the aardvark might want to use a fact that had been obtained from *The World Book Encyclopedia.* The following sentence would be awkward:

> In an article entitled Aardvark on page 2 of Volume A of *The World Book Encyclopedia*, it is stated that in the 1600's Dutch settlers in Africa gave the aardvark its name.

When a footnote is used, however, the sentence can be read quickly and easily:

> The aardvark received its name from Dutch settlers in Africa in the 1600's.[1]
>
> [1] "Aardvark," *The World Book Encyclopedia*, Vol. A, p. 2.

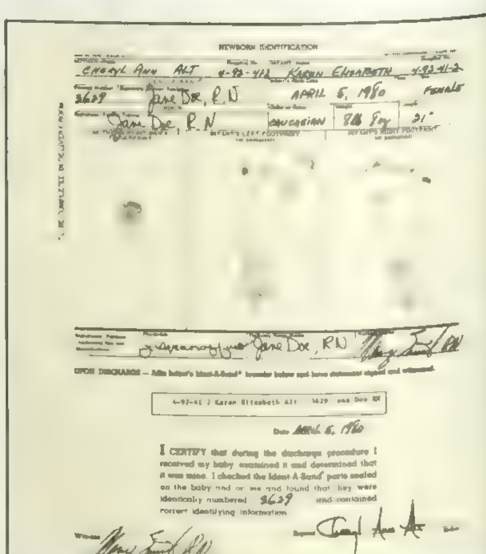
A number in small type is commonly used to draw attention to a footnote. An asterisk (*), or a dagger (†), or a double dagger (‡) may be used instead of a number.

Footnotes referring to a book should list the name of the author first, the book title second, and the page number third. Those referring to magazine articles list the author first, the title of the article second, the name of the magazine third, the volume fourth, the date of issue fifth, and the page number sixth.

Footprinting is a system of identification similar to fingerprinting. Footprints are the impressions made by ridges on the soles of the feet. Like fingerprints, footprints remain unchanged throughout a person's lifetime. No individual's footprints have been found to be identical to those of another person. Footprints found at the scene of a crime may help identify suspects. Footprints also provide a means of identification when fingerprints cannot be obtained because of severe burns or other injuries. See also **Fingerprinting.**

For the Term of His Natural Life. See **Australian Literature** (The development of the novel).

Forbes (pop. 7,552) is a town on the Lachlan River in New South Wales, Australia. It serves one of the state's most productive farming regions. Forbes has many attractive old buildings. The Lachlan Vintage Village, opened in 1975, is the most important tourist attraction in the town. George William Evans explored the region in 1815 and John Oxley visited it in 1817. Gold was discovered in the area in 1861. Two notorious bushrangers,



Footprints of a newborn baby are recorded by hospitals in some countries for identification purposes. The baby's footprints appear on a certificate along with the mother's fingerprints.

Frank Gardiner and Ben Hall, terrorized the region during the 1860's

Forbes, Esther (1891-1967), was an American author. She won the 1943 Pulitzer Prize in American history for her brilliant historical biography, *Paul Revere and the World He Lived In.* While writing this book, she became interested in the apprentice boys of Boston, and the part they played in the American Revolution. After finishing the adult biography, Forbes wrote for young people the novel *Johnny Tremain,* about an apprentice in the exciting days of the Boston Tea Party. This book won the Newbery Medal in 1944. She also wrote such American historical novels as *A Mirror for Witches* (1928), *Paradise* (1937), *The General's Lady* (1938), *The Running of the Tide* (1948), and *Rainbow on the Road* (1954).

Forbes was born in Westborough, Massachusetts, U.S.A. She studied at the University of Wisconsin.

Forbidden City. See **Beijing** (The city); **Lhasa.**

Force is any cause that changes the motion or the shape of an object. For example, when you push a cart, you apply force to make the cart move forward. When you squeeze a piece of soft clay, the force you apply changes the shape of the clay.

Many forces affect the *velocity* (speed) of a moving object. For example, when you roll a ball across a carpet, friction between the ball and the carpet acts against the motion of the ball and thus slows the ball down. Any change in velocity is called *acceleration.* A decrease in velocity is also sometimes called *negative acceleration* or *deceleration.*

There are several kinds of forces. *Mechanical forces* act when objects touch each other. Your body applies mechanical force when you pedal a bicycle or kick a football. However, electricity, gravitation, and magnetism are forces that act without contact among objects. Instead, they act over a distance, and arise from a *field* of force. For instance, the electric fields around charged particles cause these particles either to attract or to repel one another. This article deals mainly with mechanical forces.

Measuring force

The *mass* of an object and the acceleration of the object must be known in order to measure force. The mass of an object is the amount of matter it has. Mass is measured in kilograms or pounds (see **Mass**). Acceleration describes how much the velocity of an object changes. It is usually expressed by a distance divided by a time squared. For example, an object may change its velocity at a rate of 1 metre per second every second. The acceleration would then be 1 metre per second squared. This quantity can also be expressed as an acceleration of 1 metre per second per second.

Units in the metric system and in the imperial system of measurement are used to measure force. In the metric system, force is expressed chiefly in terms of *newtons.* One newton is the force required to accelerate a 1-kilogram object by 1 metre per second squared. In the English system, the basic unit of force is the *poundal.* One poundal is the force needed to accelerate a 1-pound body 1 foot per second squared.

The relationship among force, mass, and acceleration was first described by the English physicist Sir Isaac Newton in the 1600's. He stated that large forces produce greater acceleration than do small forces, and that heavy objects accelerate less rapidly than do light objects. Newton expressed the relationship among acceleration, force, and mass in the equation $F = ma$. In this equation, F equals the force applied to the object, m equals the object's mass, and a equals the acceleration produced in the object. Newton's description of the relationship among these quantities is known as his second law of motion (see **Motion** [Newton's laws of motion]).

How forces interact

In many cases, more than one force acts on an object at the same time. Such *concurrent forces* produce a single net force, also called a *resultant force.*

Concurrent forces that produce motion when they interact are called *unbalanced forces.* For example, when two people push a stalled car forward, the combined forces they apply overcome the friction between the road and the tyres. As a result, the car starts to roll forward.

Forces that do not produce motion when they interact are called *balanced forces.* For example, when you sit in a chair, the force of gravity pulls you toward the earth. At the same time, the chair pushes you upward, away from the earth. The force of the chair cancels out the force of gravity, and you remain stationary. A person or object acted upon by balanced forces in this way is said to be *in equilibrium.*

Calculating resultant force

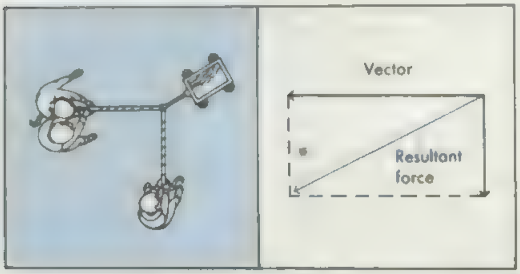
To calculate the resultant force, a person needs to know the direction and magnitude of the concurrent forces. If the concurrent forces act in the same direction, then the resultant force also acts in that direction. The magnitudes of the concurrent forces are simply added to determine the magnitude of the resultant force. If two concurrent forces operate in opposite directions and have unequal magnitudes, then the resultant force acts in the direction of the stronger force. The magnitude of the resultant force equals the difference in magnitudes between the two concurrent forces.

Many concurrent forces act at an angle to each other. Quantities called *vectors* are used to calculate the resultant of such forces. A vector tells the magnitude of a force and the direction in which it operates. It can be represented by an arrow—also called a vector—that points in the direction of the force. The length of the arrow indicates the magnitude of the force. Any scale may be chosen when drawing vectors. The point of the arrow is called its *head* and the opposite end, its *tail.*

There are three main methods of using vectors to determine resultant force: (1) the parallelogram method, (2) the polygon method, and (3) the analytical method.

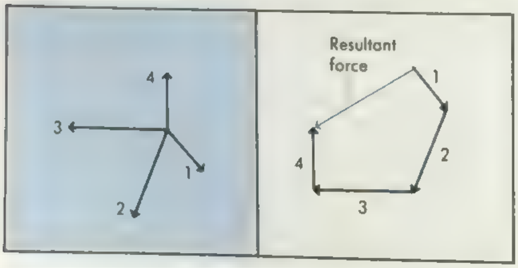
The parallelogram method is used for calculating the resultant force of only two concurrent forces at a time. In this method, the vectors that represent the concurrent forces are used to construct a parallelogram. For example, suppose that two forces act at an angle to each other. After choosing a scale, draw these forces as vectors whose tails join at a single point. This point represents the object upon which the forces act. Next, construct a parallelogram, using the two vectors as two sides of the figure. Then draw the *diagonal* of the parallelogram—that is, draw a line from the point that

represents the object to the opposite corner. Next, make the diagonal into a vector pointing away from the object. This vector represents the resultant force. To determine the magnitude of the resultant force, simply measure the length of its vector.



The parallelogram method is a technique for determining the *resultant force* (net force) of two forces acting on an object. In the diagram on the left above, three children exert two forces on a wagon by pulling on two ropes. In the diagram on the right, arrows called *vectors* show the direction and size of the two forces. These vectors are then used to construct a parallelogram. The diagonal of the parallelogram represents the resultant force applied to the wagon.

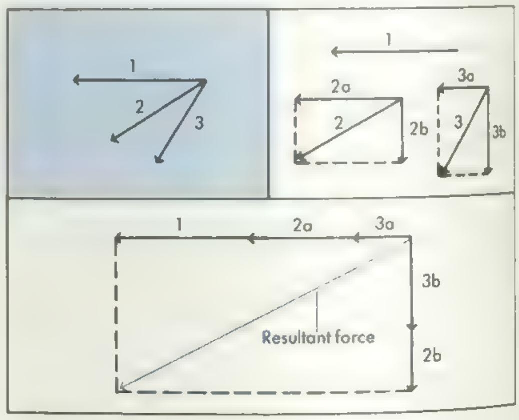
The polygon method is used to calculate the resultant force when more than two concurrent forces interact. In this method, vectors that represent concurrent forces are used to construct a polygon. These vectors are drawn one after the other, with the head of the first vector joined to the tail of the second vector, and so on. A final vector is drawn to connect the tail of the first vector to the head of the last vector. This new vector completes the polygon and represents the resultant force. It should point away from the tail of the first vector.



The polygon method enables physicists to analyse the interaction of three or more forces. Vectors representing these forces are used to construct a polygon. The vector drawn to complete the polygon shows the resultant force.

The analytical method is also used to find the resultant force when more than two forces interact. This method is based on the fact that any vector can be expressed as the resultant of two smaller vectors that are at right angles to each other. For example, a 5-newton vector can be expressed as the resultant of a 4-newton vector and a 3-newton vector that are at right angles to each other. In this example, the 5-newton vector is the *hypotenuse* of the triangle that it forms with the 4-newton vector and the 3-newton vector. The square of the 5-newton vector (25) is therefore equal to the sum of the squares of the two other vectors (9 + 16). For a complete explanation of this principle, see **Pythagorean Theorem.**

With the analytical method, each concurrent force is first expressed as a vector. All but one of the vectors are then broken down into smaller vectors that act at right angles to each other. One vector of each pair acting at right angles is drawn parallel to the vector that has not been broken down. Next, those vectors that are pointing in the same or opposite directions are added. The additions result in a pair of vectors at right angles to each other. The resultant force for this pair of vectors can then be calculated using the parallelogram method. This force is also the resultant force of the original concurrent forces.



The analytical method is used to calculate resultant force when several forces interact. The method is based on the fact that any force, such as number 2, *above*, can be expressed as the resultant force of two smaller forces, such as 2a and 2b.

Fundamental forces

Physicists consider all forces in the universe to be forms of four fundamental forces. These basic forces—from the weakest to the strongest—are (1) gravitation, (2) the weak nuclear force, (3) electromagnetism, and (4) the strong nuclear force. The weak nuclear force and the strong nuclear force are also known as the *weak interaction* and the *strong interaction.*

Gravitation exerts influence over great distances in space. It works most effectively on large masses. For example, the sun's gravity holds the earth in its orbit. The electromagnetic force operates over much shorter distances than does gravitation. Electromagnetism holds molecules together. The weak and strong nuclear forces act within the nuclei of atoms.

Related articles in *World Book* include:

Antigravity
Centrifugal force
Centripetal force
Cohesion
Dynamics
Dyne
Electric field
Electricity
Electromotive force
Energy
Friction
Grand unified theories
Gravitation
Gyroscope
Inertia
Jet propulsion
Magnet and magnetism
Moment
Newton
Newton, Sir Isaac
Physics
Power
Pressure
Statics
Strength of materials
Torque
Weight

Ford is a place where a stream or river can be crossed. During early times, people had to cross a waterway by wading through or swimming across its shallow part. During wartime, soldiers must often *ford* (cross) water where bridges have been blown up. They sometimes do this by placing *pontoons* (portable floats) in a line across the water. See also **Pontoon bridge.**

Ford, Ford Madox (1873-1939), was an English author of complex and symbolic novels which show the influence of the psychological novels of Henry James. In *The Good Soldier* (1915), his best-known work, Ford revealed with keen irony the declining influence of the upper class in English life. This novel was followed by the series called *Parade's End,* which consists of *Some Do Not* (1924), *No More Parades* (1925), *A Man Could Stand Up* (1926), and *The Last Post* (1928). The series traces changes in English society during and after World War I. Ford and Joseph Conrad wrote two novels together, *The Inheritors* (1901) and *Romance* (1903).

Ford Madox Ford

Ford was born Ford Madox Hueffer in London. He edited two famous literary magazines, the *English Review* and the *Transatlantic Review,* and was writer-in-residence at Olivet College, Michigan, U.S.A., from 1937 until his death.

Ford, Gerald Rudolph (1913-), was president of the United States from 1974 to 1977. A Republican, he was the only person to serve as both vice president and president who did not win election to either office.

President Richard Nixon appointed Ford vice president in 1973. Ford became president on Aug. 9, 1974, upon Nixon's resignation. At the time, Nixon faced almost certain impeachment for his role in the Watergate scandal. As president, Ford pardoned Nixon for all federal crimes Nixon may have committed as chief executive. The action was controversial and probably contributed to Ford's defeat by Jimmy Carter in the 1976 election. See **Nixon, Richard M.**

Gerald R. Ford

Ford was born Leslie Lynch King, Jr., in Omaha, Nebraska, U.S.A. He took the name Gerald Ford from his stepfather. Beginning in 1948, he was elected to 13 successive terms in the U.S. House of Representatives.

Ford, Henry (1863-1947), was a leading American manufacturer of cars in the early 1900's. He established the Ford Motor Company, which revolutionized the motor industry with its assembly line method of production. The savings from this technique helped Ford sell cars at a lower price than anyone had before. From 1908 to 1927, more than half the cars sold in the United States were Fords.

Early life. Ford was born on a farm in what is now Dearborn, Michigan, U.S.A. He became a machinist at the age of 16 and later worked as an engineer at a Detroit electric company. As a young man, Ford became interested in motor cars, which were then a new invention. He built his first successful petrol engine in 1893 and his first car in 1896.

Industrial accomplishments. In 1903, Ford founded the Ford Motor Company. At first, the company produced only expensive cars, as its competitors did. However, Ford soon began working to make a simple, sturdy car that large numbers of people could afford. He achieved one of the first such cars with the Model T, which appeared in 1908. In 1909, Ford decided to produce only Model T's.

The Model T's original price of 850 U.S. dollars was too high for many customers. To lower the price, Ford created an assembly line method in which conveyor belts brought car parts to workers. Each worker performed a particular task, such as adding or tightening a part. This system helped reduce the assembly time of a Ford car from about 12½ worker-hours in 1912 to about 1½ worker-hours in 1914.

Ford Motor Company began to produce its own parts instead of buying them from independent suppliers at a higher price. Ford also shipped car parts, rather than assembled cars, to market areas, where assembly plants put the parts together. Parts cost less to transport than whole cars did. In addition, the company began to make its own glass and steel.

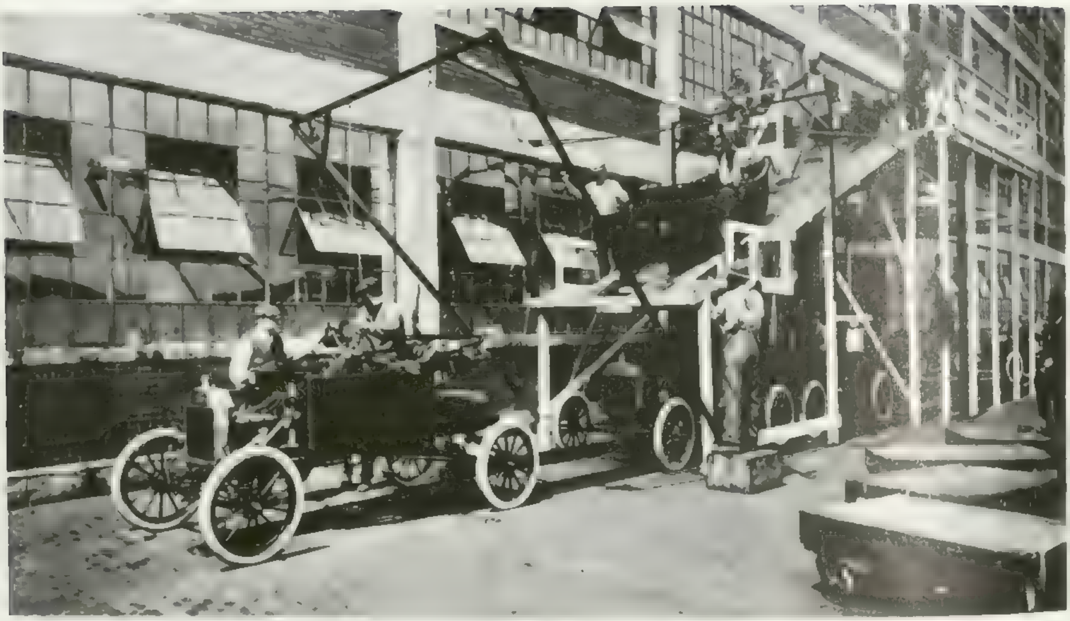
As the company's production costs fell, Ford passed much of the savings on to his customers. The price of a Model T dropped to 500 U.S. dollars in 1913, 390 U.S. dollars in 1915, and 260 U.S. dollars in 1925, putting the car within reach of the average family.

In 1914, Ford raised the minimum wage for his employees, paying more than twice what most wage earners received. Ford also reduced the working day from 9 to 8 hours. Workers flocked to Ford plants seeking jobs. To encourage productivity, Ford introduced a profit-sharing plan, which set aside part of the company's profits for its employees. Ford also located plants abroad.

During the late 1920's, the success of the Model T was challanged by the U.S. General Motors Corporation (GM). GM offered a wide range of models, and introduced new designs each year. Ford, however, continued to offer only a basic model at a low cost. The Model T changed little from year to year, and until 1926 it came in only one colour, black.

Ford finally introduced a new design, the Model A, in 1927, after more than 15 million Model T's had been sold. In 1932, Ford introduced the first low-priced car with a *V-8 engine,* a powerful engine that had eight cylinders arranged in a V. By that time, however, GM had taken the lead

Henry Ford



An assembly line in 1914 was used to build Model T cars in Highland Park, Michigan, U.S.A.

from the Ford Motor Company in home car sales. The Ford Motor Company's sales declined still further throughout the 1930's, and some people began to question Henry Ford's management skills. In 1945, Henry Ford II, one of Ford's grandsons, took over the company.

Political and charitable activities. Ford had long taken an interest in political affairs. In 1915, during World War I, he and about 170 other people travelled to Europe at his expense to seek peace. The group, which lacked the approval of the United States government, failed to persuade the warring nations to settle their differences.

Oil painting on canvas (early 1950's) by Norman Rockwell, Henry Ford Museum and Greenfield Village, Dearborn, Michigan, U.S.A.

Henry Ford's first car was built in a workshop in Detroit. The car, completed in 1896, is now on display at the Henry Ford Museum in Dearborn, Michigan, U.S.A.

Ford devoted much time and money to educational and charitable projects. He established two museums Greenfield Village and the Henry Ford Museum, both in Dearborn, Michigan, U.S.A. In 1936, Ford and his son, Edsel, established the Ford Foundation, the world's largest foundation, which provides grants for education, research, and development. The foundation became a national organization in 1950, and today has offices in other countries besides the United States.

See also **Car** (Henry Ford); **Ford, Henry, II; Ford Motor Company.**

Ford, Henry, II (1917-1987), was an American car manufacturer who reorganized the Ford Motor Company during the 1940's and rescued it from near bankruptcy. He was a grandson of Henry Ford, who founded the company in 1903.

Henry Ford II was born in Detroit. During World War II (1939-1945), he served in the United States Navy. In 1943, he was released from the Navy to help the Ford Motor Company, which produced military vehicles and other supplies for the war effort.

Ford became vice president of the company in 1943 and took over the presidency from his grandfather in 1945. At that time, the company was losing about 9 million U.S. dollars a month. Ford hired a team of expert managers to help him reorganize the company. He also introduced new marketing methods and car models to meet the changing tastes of the American public. By 1949, the company was back in profit.

See also **Ford, Henry; Ford Motor Company.**

Ford, John (1586-1639?), was an English dramatist. Many critics of the 1900's, particularly T. S. Eliot, ranked several of Ford's tragedies as second only to those of Shakespeare.

Two of Ford's tragedies, *The Broken Heart* (1629) and *'Tis Pity She's a Whore* (about 1633), appeal to today's audiences because of the modern psychology of the characters' motivations. Both of these plays concern the power of love and the tragedy resulting from its frustrations. *'Tis Pity She's a Whore,* because its subject is incest, verges on sensationalism, yet it is only a plot like *Romeo and Juliet* developed with more highly individualized psychology.

Little is known of Ford's life. He was connected with the legal profession and may have turned to writing plays to increase his income. His dramas apparently were not popular in his own time.

Ford, John (1895-1973), an American film director, was the first to win Academy Awards for four films. He won the awards for *The Informer* (1935), *The Grapes of Wrath* (1940), *How Green Was My Valley* (1941), and *The Quiet Man* (1952). Ford became famous for staging outdoor films with a keen sense of background and deep feeling for people. His major outdoor and Western films include *The Iron Horse* (1924), *The Hurricane* (1937), *Stagecoach* (1939), *Fort Apache* (1948), *She Wore a Yellow Ribbon* (1949), *Wagonmaster* (1951), *Mogambo* (1952), *The Horse Soldiers* (1959), and *Cheyenne Autumn* (1964).

John Ford

Ford was born in Portland, Maine, U.S.A. His real name was Sean Aloysius O'Feeney. Ford began his directing career in 1914 and directed more than 200 films. In 1973, U.S. President Richard Nixon awarded Ford the Presidential Medal of Freedom.

Ford Motor Company ranks as one of the giants of world industry. The company manufactures various models of Ford, Lincoln, and Mercury cars. It also makes Ford trucks and tractors, farm machinery, and industrial engines and accessories. Apart from its vehicle business, the Ford Motor Company owns other companies within finance and insurance, land development, and steel-making.

Ford has about 75 assembly and manufacturing plants in the United States. The largest Ford manufacturing centre in the U.S.A. is the Rouge complex near Detroit. The plant covers 450 hectares and employs 16,000 people. The Rouge plant has its own dock for lake vessels.

Ford also has manufacturing subsidiaries in Australia, Belgium, Canada, France, Germany, Great Britain, Mexico, Spain, and Venezuela, and maintains other sales and assembly facilities in Europe and South America. Ford is a joint owner of manufacturing companies in Argentina, Brazil, Malaysia, New Zealand, Taiwan, and Turkey.

Henry Ford founded the company in 1903. The success of the Model N, brought out in 1906, led to the introduction of the famous Model T in 1908. Affectionately known as the "Tin Lizzie," this simple and inexpensive car became very popular. All but the body of the Model T could be assembled in 93 minutes on an assembly line established at the Ford factory in Highland Park, Michigan, U.S.A., in 1913. The Model T gave way to the Model A in 1927. In 1932, Ford brought out the V-8 engine.

Ford family interests controlled the company until 1956. In January 1956, the Ford Foundation sold 10,200,000 shares of its Ford company stock to the public. This was the largest single stock issue ever offered in the United States to the public up to that date. With this sale, the Ford Motor Company became a publicly owned company. It has about 270,000 stockholders.

See also **Ford, Henry; Ford, Henry, II.**

Forde, Francis (1890-1983), an Australian politician, was prime minister of Australia from July 6 to July 12, 1945. During World War II, he was deputy prime minister to John Curtin and minister for the Army. When Curtin died, Forde succeeded him. Six days later, Ben Chifley was elected prime minister. Francis Michael Forde was born at Mitchell, in Queensland, Australia. He entered the federal Parliament in 1922. In 1929, he became a minister in the Labor government. In 1932, the Australian Labor Party elected him deputy leader. From 1946 to 1953, he was Australian high commissioner in Canada.

Fordyce, Bruce (1955-   ), a South African long distance runner, became one of his country's greatest athletes.

Bruce Noel Stevenson Fordyce was born in Hong Kong. He arrived in South Africa with his family at the age of one. He was educated in South Africa and gained a Master of Arts degree in archaeology from the University of Witwatersrand, Johannesburg.

Fordyce began running in 1976, and won his first race at Springs in 1977. That year, he also ran in the Comrades Marathon for the first time. This course stretches from Pietermaritzburg to Durban, a distance of about 90 kilometres. The race was first held in 1921. It is named after the Comrades of the Great War, an organization of South African veterans of World War I (1914-1918). Today it ranks as South Africa's greatest single sporting event. Between 1981 and 1990, Fordyce won the race nine times. His first win was in the record time of 5 hours 37 minutes 28 seconds. From then on, Fordyce won the race every year until 1988. He did not compete in 1989, but he won the race again in 1990. Fordyce has also won a number of distance races in many other parts of the world.

Forearm. See Arm.

Forecasting, Weather. See Weather (with pictures); Meteorology.

Foreclosure. See Mortgage.

Foreign and Commonwealth Office. See United Kingdom, government of.

Foreign bill of exchange. See Economics (World finance).

Foreign exchange. See Money (table: Exchange rates); International trade (Financing international trade); Economics (World finance).

Foreign language study. See Language (Learning a foreign language).

Foreign Legion is one of the world's most colourful and gallant fighting forces. The Legion is a unit of the French government and is called the *Légion Étrangère* in French. It consists of volunteers. Most Legionnaires come from countries other than France. Frenchmen are forbidden to join the Legion, but some enlist by giving false nationalities.

Men who apply for duty in the Legion must be between 18 and 40 years old. They must pass a strict physical examination to be accepted. Legionnaires enlist for five years.

The Legion does not make its records public, and an atmosphere of mystery, exaggeration, and glamour surrounds it. Some men join the Legion to escape political punishment, and others to seek adventure. Still others join to avoid punishment for crime. However, the Legion accepts no known criminals, and the number of criminals in the unit has been exaggerated in many fictional accounts. Doctors, lawyers, merchants, and priests have served in the Legion. Whatever their reasons for joining the force, the Legionnaires rank among the world's best soldiers.

Discipline in the Legion is harsh. But the unit never lacks recruits. About 350,000 men have served in the Legion. Today, it has about 8,000 members. Headquarters are in Aubagne, France, just outside Marseille.

Louis Philippe created the Legion in 1831, for service outside France. Its original purposes were to offer a haven for foreign mercenaries serving in the Swiss Guard, and to assist in the conquest of Algeria, a country in North Africa. A total of 4,000 men, most of them Poles, Spaniards, Germans, and Italians, were organized into nationalistic battalions. Each group of men spoke its own language. The Legion's flag then, as now, was the tricolour, on which appears a globe marked *France* and the words: "The King of the French to the Foreign Legion."

The Legion's most famous uniform consisted of baggy red trousers and a high-collar blue coat. During World War I (1914-1918), the Legion wore the blue of the French army. Shortly after the war, it adopted the present khaki uniform. The Legion's insignia is a small red grenade that spouts seven flames.

The Legion has served most frequently in colonial wars. But it has also participated in France's major wars. After its work in Algeria, it fought for Spain in the Carlist War of 1835. Only 500 men survived the three years in Spain and returned to Algeria.

Over the next 50 years, the Legion was involved in subduing and making peace with the people of Algeria and Morocco, also in North Africa. When it was not fighting, it was erecting buildings. Legionnaires constructed the first European-style buildings in almost every city in North Africa. During these 50 years, the Legion also fought elsewhere, and underwent organizational changes.

In 1854, two regiments fought in the Crimean War against Russia. About 450 Legionnaires were killed in the war. In 1859, two regiments fought the Austrians in Italy, in an attempt to revive France's empire. Nearly 150 Legionnaires died in the campaign. In 1863, Napoleon III involved the Legion in another desperate and hopeless cause. The Legion formed part of the French army sent to Mexico to support Maximilian's attempt to seize authority in that country. In that campaign, which lasted until 1867, the Legion lost about 470 men.

A handful of Legionnaires bravely fought the Battle of Camerone in Mexico on April 30, 1863. The date of that battle is considered the sacred date of the corps, and Legionnaires throughout the world observe it each year. They conduct memorial services, and retell the story of the men who withstood the assaults of 2,000 enemy soldiers and refused to surrender. Of the last six Legionnaires who made a final bayonet charge, three survived and were captured. The officer in charge lost his wooden hand. It now rests in a place of honour in the Legion's Hall of Fame in Aubagne, France.

When Germany invaded France in 1870, the Legion sent help to the mother country. Their capture of Orléans was the only bright spot in the tale of French resistance. In 1885, four battalions went to Indochina (an area consisting of Cambodia, Laos, and Vietnam) to protect that colony against local uprisings. After successfully accomplishing this mission, the units were organized into the Fifth Regiment, and stationed permanently in Indochina.

During World War I, the first two regiments of the Legion supplied four other regiments for service in France. About 45,000 Legionnaires fought Germany. Of these, nearly 31,000 were killed, wounded, or missing in action. As a result of its gallant actions, the Legion became one of the most decorated French military units of World War I.

In World War II (1939-1945), Legionnaires served in many parts of the world. At first, they fought the Japanese in Indochina, and against Nazi Germany in France and Norway. Later, some units fought for Vichy France before it was occupied by German troops. But most units joined General Charles de Gaulle and served in North Africa, France, and Germany.

After World War II, the Legion again became a haven for political refugees and former soldiers, particularly Germans. With up-to-date equipment, it was again called upon to fight in Indochina from 1946 to 1954, this time against Communist rebels. The Legion sparked the final heroic resistance at Dien Bien Phu, in what is now northwestern Vietnam.

When Algeria became independent in 1962, Legion headquarters moved from Sidi Bel Abbès, Algeria, to Aubagne, France. Over the years, most of the Legion's units moved out of Africa. In 1984, one unit serving in Lebanon was the target of Muslim terrorist attacks. Today, the majority of the units are stationed in France and the Pacific islands controlled by France.

Foreign office. See Foreign service.

Foreign relations. See International relations.

Foreign service is the main organization through which a country's international affairs are conducted. The foreign service is administered by a government department. Other agencies may be involved in specialist areas of foreign affairs. The foreign service provides trained personnel for *embassies* (offices) in foreign countries. Some members of the foreign service work in the government department responsible for foreign affairs, usually known as the foreign ministry or foreign office. In the United Kingdom, this department is called the Foreign and Commonwealth office. In the United States, it is the Department of State. Members of the foreign service are sometimes known as diplomats, because their work involves *diplomacy* (negotiations with foreign governments over such matters as trade treaties, or the settling of disputes). See **Diplomacy**.

Many countries maintain embassies in foreign countries around the world. Smaller foreign service offices are called *consulates* or *missions*. Members of the Com-

monwealth of Nations call their foreign service offices in each other's countries *high commissions.* These offices are staffed by members of the diplomatic service, sent out from the home country. Some have staff recruited in the host country.

An embassy is regarded as part of a home country's territory, and the host country may not interfere with the building or with the people within it. The embassy serves as a point of contact with the host country, and its head is called an *ambassador.* Generally, he or she is a senior diplomat whose career is spent within the foreign service. Senior staff in the foreign service are experienced in management and the development of policy. They have wide knowledge of the culture, economics, history, and language of various nations. Not all ambassadors are career diplomats. An ambassador may be a political appointee, chosen by the government for his or her suitability for a particular posting.

The work of an embassy includes protecting the home country's commercial and political interests through negotiations with government officials of other countries. Foreign service officials report to senior staff on economic, social, and political conditions. They issue passports or visas to travellers. Officials protect the interests and welfare of their country's citizens abroad. And they interpret their government's policies to governments and citizens of other countries. Some members of the foreign service perform specialized tasks in economics, international commercial and trade union affairs, or administration.

Most newly appointed officers are trained within their foreign ministry before being posted abroad. They learn the languages and customs of other countries, receive advanced instruction in international relations, and study specific policies relating to their future work. Many will serve overseas for periods of five to seven years out of every ten years. Others will be employed at home. The United States Foreign Service, for example, employs approximately 14,000 people, of whom 8,000 work in the United States. Applicants to the foreign service of any country must normally be citizens of that country. Appointments are often made on a competitive basis, through a written examination and subsequent detailed evaluation.

History. Diplomacy developed as countries built up relations with one another, and sought ways of establishing peaceful trade and commerce. Passports were originally issued to safeguard the rights of people travelling abroad. Ambassadors were sent to the courts of foreign kings, sometimes to arrange a marriage, or to negotiate an alliance. Secrecy was generally regarded as important in such negotiations. Spying was also frequently part of the foreign service's duties. Often the ambassador had to pay his own travel expenses and provide his own living quarters.

By the 1800's, many governments in Europe and elsewhere had set up foreign services. People working for the foreign service were regarded as a civil servants, and were paid a salary. The idea of "diplomatic immunity" had developed. This meant that diplomats enjoyed special privileges. For example, they could not be arrested and their homes were sanctuaries, or asylums, where refugees could be safe from capture. In time, it became standard practice in many countries for most foreign service employees to be career civil servants. They retained their posts when there was a change of government.

During the colonial period, countries within the British Empire had no foreign services of their own. Australia, for instance, followed British foreign policy and had no overseas diplomats except for representatives in Britain. In 1935, Australia set up a department of external affairs to administer a specifically Australian foreign policy, and in 1940, it sent its first diplomats to Japan and the United States. Today, all Commonwealth members maintain their own foreign services.

In the modern foreign service, with fast communication by radio and telephone between embassy and central government, the ambassador or consul no longer has much power of individual action. Heads of state nowadays meet face-to-face at "summit talks," or at regular gatherings such as the Commonwealth heads of state meetings. Negotiations have become less secret. But still months of behind the scenes work may precede diplomatic moves, such as a new trade treaty or a peaceful resolution to a border dispute.

Today, a country's foreign service is an influential branch of government, helping to shape foreign policy and smoothing day-to-day business between nations. Changes in foreign policy affect the foreign service's role. For example, Britain's foreign service has lost its former role of administering a worldwide empire. Instead, British foreign policy is more and more centred on Europe, and seeking common approaches to international affairs with other members of the European Community.

Now that countries such as Australia or India have weakened their ties with Britain, their foreign services have become increasingly concerned with affairs in their own part of the world. Developing trade and other links with near neighbours forms a large and important part of this work.

As well as working within their country's foreign ministry, foreign service employees may now also work for other departments and agencies. Foreign service work includes overseas aid and development, agriculture, trade and industry, and tourism and travel.

See also **Ambassador; Consul; Diplomacy; Diplomatic corps.**

Foreign trade. See **International trade.**

Forensic ballistics. See **Ballistics** (Forensic ballistics).

Forensic science. See **Police laboratory.**

Foreordination is the belief that every event is *foreordained,* or decreed beforehand, by God. Supporters of this doctrine argue that if God does not ordain every event, He cannot be said to be all-powerful. Foreordination in its extreme form teaches that, by God's mysterious choice, some people are destined for hell and other people are destined for heaven.

Many religious traditions have taught some form of foreordination. But it is most often associated with the leader of the Protestant Reformation, John Calvin, whose ideas influenced the Congregationalists, Baptists, Presbyterians, and Episcopalians (see **Calvin, John**). In recent years, most churches have moderated or ceased to emphasize the doctrine of foreordination.

See also **Predestination.**

Boreal forest

Temperate deciduous forest

Temperate evergreen forest

Different kinds of forests grow in different parts of the world. It is possible to divide the world's forests into the nine *formations* (types) shown in the photographs above and on the next two pages. The forests that make up each formation have similar plant and animal life.

Forest

Forest is a large area of land covered with trees. But a forest is much more than just trees. It also includes smaller plants, such as mosses, shrubs, and wild flowers. In addition, many kinds of birds, insects, and other animals make their home in the forest. Millions upon millions of living things that can only be seen under a microscope also live in the forest.

Climate, soil, and water determine the kinds of plants and animals that can live in a forest. The living things and their environment together make up the forest *ecosystem.* An ecosystem consists of all the living and nonliving things in a particular area and the relationships between them.

The forest ecosystem is highly complicated. The trees and other green plants use sunlight to make their own food from the air and from water and minerals in the soil. The plants serve as food for certain animals. These animals, in turn, are eaten by other animals. After plants and animals die, their remains are broken down by bacteria and other organisms, such as protozoans and fungi. This process returns minerals to the soil, where they can again be used by green plants.

Many forest trees live for hundreds of years. When they die, they fall to the forest floor and decay, adding to the fertility of the soil. The dead trees are replaced by new trees, which appear as seedlings in gaps in the woodland. If the forest is wisely managed, it provides us with a continuous source of wood and other products.

Before people began to clear the forests for farms and cities, great stretches of forestland covered about 60 per cent of the earth's land area. Today, forests occupy only about 25 per cent of the land. The forests differ greatly. For example, the steamy, vine-choked rain forests of central Africa are very different from the cool towering spruce and fir forests of northern Canada.

This article provides information on the importance of forests and describes their structure. It also discusses the major kinds of forests in the world, describes how forests function as an ecosystem, and explains how forests have changed and developed through the ages. Finally, the article describes how human activities have destroyed many forested areas. For detailed information on forest products and forest management, see the articles **Forest products** and **Forestry.**

The importance of forests

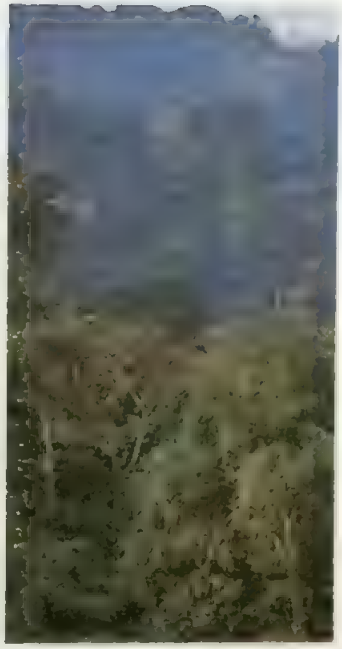
Forests have always been of great importance to human beings. Prehistoric people found their food mainly by hunting and by gathering wild plants. Many of these people lived in the forest and were a natural part of it. With the development of civilization, people settled in towns and cities. But they still returned to the forest to get timber and to hunt.

Today, people depend on forests for (1) their economic value, (2) their environmental value, and (3) their value for culture and recreation. The science of forestry is concerned with good management of forests.

Economic value. Forests supply many products. Wood from trees provides timber, plywood, railway


Mediterranean forest


Tropical rainforest


Tropical seasonal forest

sleepers, and sawdust. It is also used in making furniture and other products. In many parts of the world, wood serves as the chief fuel for cooking and heating.

Various manufacturing processes change wood into a great number of different products. Paper is one of the most valuable products made from wood. Other processed wood products include cellophane, plastics, and such fibres as rayon and acetate.

Forests provide many important products besides wood. Latex, which is used in making rubber, and turpentine come from forest trees. Various fats, gums, oils, and waxes used in manufacturing also come from trees. In some tribal societies, forest plants and animals make up a large part of the people's diet.

Unlike most other natural resources, such as coal, oil, and mineral deposits, forest resources are potentially renewable. As long as there are forests, people can count on a steady supply of forest products.

Environmental value. Forests help conserve and enrich the environment in several ways. For example, forest soil soaks up large amounts of rainfall. It thus prevents the rapid runoff of water that can cause erosion and flooding. In addition, rain is filtered as it passes through the soil and becomes *ground water.* This ground water provides a clean, fresh source of water for streams, lakes, and wells.

Forest plants and soils interact with the atmosphere by absorbing and releasing such gases as oxygen, carbon dioxide, and methane. For example, leaves absorb carbon dioxide as part of *photosynthesis,* the food-making process of green plants. Trees release carbon dioxide as they die, rot, or burn. Carbon dioxide helps to regulate the climate. The more carbon dioxide in the atmosphere, the warmer the temperature will be.

Forests also regulate the climate more directly. For example, they shade the ground from the sun. Rainforests, especially in the tropics, generate rain because much of the rainfall never reaches the ground, but is evaporated from the leaves back into the air. This keeps the atmosphere moist and creates new rain clouds.

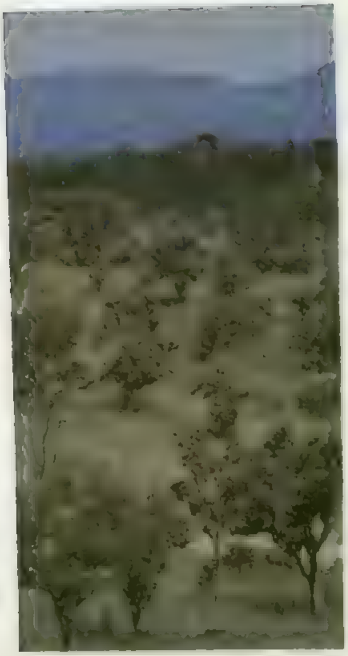
Forests also provide a home for many plants and animals that can live nowhere else. Without the forest, many kinds of wildlife could not exist. About half of all species of plants, animals, and insects live in forests, many of them in tropical forests.

Value for culture and recreation. Forests are home to many tribal communities. Forests provide not only food, water, and the materials for everyday living, but also a spiritual and cultural home. Tribal people also designate many forests as sacred burial grounds. For other people, the natural beauty and peace of the forest offer a special source of enjoyment. In many countries, huge forestlands have been set aside for people's enjoyment. Many use these forests for such activities as camping, hiking, and hunting. Others visit them simply to enjoy the scenery and to relax in the quiet beauty.

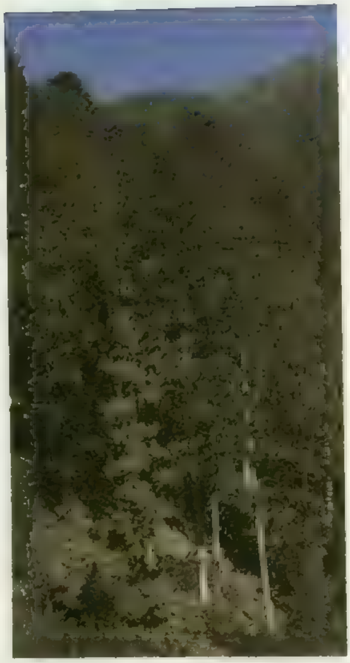
The structure of forests

Every forest has various *strata* (layers) of plants. The five basic forest strata, from highest to lowest, are (1) the canopy, (2) the understorey, (3) the shrub layer, (4) the herb layer, and (5) the forest floor.

The canopy consists mainly of the *crowns* (branches and leaves) of the tallest trees. The most common trees in the canopy are called the *dominant* trees of the forest. Certain plants, especially climbing vines and epiphytes, may grow in the canopy. *Epiphytes* are plants that grow on other plants for support but may absorb from the air



Savanna



Mountain forest

Bamboo forest

the water and other materials they need to make food.

The canopy receives full sunlight. As a result, it produces more food than does any other layer of the forest structure. In some forests, the canopy is so dense it almost forms a roof over the lower strata. Fruit-eating birds, and insects and mammals that eat leaves or fruit, live in the canopy.

The understorey is made up of trees shorter than those of the canopy. Some of these trees are smaller species that grow well in the shade of the canopy. Others are young trees that may in time join the canopy layer. Because the understorey grows in shade, it is not as productive as the canopy. However, the understorey provides food and shelter for many forest animals.

The shrub layer consists mainly of shrubs. Shrubs, like trees, have woody stems. But unlike trees, they have more than one stem, and none of the stems grows as tall as a tree. Forests with a dense canopy and understorey may have only a patchy shrub layer. The trees in such forests filter out so much light that few shrubs can grow beneath them. Most forests with a more open canopy and understorey have heavy shrub growth. Many birds and insects live in the shrub layer.

The herb layer consists of ferns, grasses, wild flowers, and other soft-stemmed plants. Tree seedlings also make up part of this layer. Like the shrub layer, the herb layer grows thickest in forests with a more open canopy and understorey. Yet even in forests with dense tree layers, enough sunlight reaches the ground to support some herb growth. The herb layer is the home of forest animals that live on the ground. They include such animals as insects, spiders, mice, birds, bears, and deer.

The forest floor is covered with moss and with the debris from the upper layers. Leaves, twigs, and animal droppings—as well as dead animals and plants—build up on the forest floor. Among this debris, a number of small organisms can be found. They include earthworms, fungi, insects, and spiders, plus countless bacteria and other forms of microscopic life. All these organisms break down the waste materials into the basic chemical elements necessary for new plant growth.

Kinds of forests

Many systems are used to classify the world's forests. Some systems classify a forest according to the characteristics of its dominant trees. A *needleleaf forest,* for example, consists of a forest in which the dominant trees have long, narrow, needlelike leaves. Such forests are also called *coniferous* (cone-bearing) because the trees bear cones. The seeds grow in these cones. A *broadleaf forest* is made up mainly of trees with broad, flat leaves. Forests in which the dominant trees shed all their leaves during certain seasons of the year, and then grow new ones, are classed as *deciduous forests.* In an *evergreen forest,* the dominant trees shed old leaves and grow new ones continuously and so remain green all year.

In some other systems, forests are classified according to the usable qualities of the trees. A forest of broadleaf trees may be classed as a *hardwood forest* because most broadleaf trees have hard wood, which makes fine furniture. A forest of needleleaf trees may be classed as a *softwood forest* because most needleleaf trees have softer wood than broadleaf trees have.

Many scientists classify forests according to various *ecological systems.* Under such systems, forests with similar climate, soil, and amounts of moisture are grouped into *formations.* Climate, soil, and moisture determine the kinds of trees found in a forest formation. The world's forests may be grouped into the following major types: (1) boreal forests, (2) temperate deciduous

forests, (3) temperate evergreen forests, (4) Mediterranean forests, (5) tropical rainforests, (6) tropical seasonal forests, (7) savannas, (8) mountain forests, and (9) bamboo forests.

Boreal forests are found in regions that have an extremely cold winter and a short growing season. The word *boreal* means *northern*. Vast boreal forests stretch across northern Europe, Asia, and North America.

Boreal forests, which are also called *taiga*, have the simplest structure of all forest formations. They have only one uneven layer of trees, which reaches up to a height of about 20 metres. In most boreal forests, the dominant trees are needleleaf evergreens—either spruce and fir or spruce and pine. The shrub layer is patchy, though small berry-bearing bushes, such as bilberry, are common. Mosses and lichens form a thick layer on the forest floor and also grow on the tree trunks and branches. There are few flowering plants.

The boreal forest of Russia stretches for over 10,000 kilometres from the Baltic Sea in the west to the Pacific Ocean in the east. The western part of the taiga is made up mainly of Norway spruce, Siberian spruce, Siberian stone fir, and Siberian stone pine. The most common

The structure of the forest

Every forest has various *strata* (layers) of plants. The five basic strata, from highest to lowest, are (1) the canopy, (2) the understorey, (3) the shrub layer, (4) the herb layer, and (5) the forest floor. This illustration shows the strata as they might appear in a temperate deciduous forest.

tree of the eastern taiga is the Daurian larch. It can grow in poor soil and has a widely spreading, shallow root system that can tap the water that lies above the *permafrost* (permanently frozen ground). The Russian taiga is broken up by areas of waterlogged marshy ground, and by many rivers that flow into the Arctic Ocean.

Many small mammals, such as mice and voles, live in boreal forests. Larger mammals include bears, beavers, elk and moose, foxes, and wolves. Birds include crossbills, grouse, hawks, nutcrackers, owls, warblers, and woodpeckers. Many birds and mammals depend on the seeds of needleleaf trees for food.

Temperate deciduous forests grow in regions with a *temperate* (moderate) climate—that is, with a warm summer, a cool winter, and a good supply of rainfall throughout the year. Temperate deciduous forests are made up mostly of broadleaf deciduous trees, which shed their leaves in the autumn. They are found in eastern North America, central and western Europe, and eastern Asia, notably in China, Japan, and Korea. These forests have developed largely since the last ice age, about 10,000 years ago. Because they grow on fertile soils, many have been cleared for agriculture.

The canopy of temperate deciduous forests reaches to between 30 and 50 metres high. The understorey, shrub, and herb layers may be dense. Plants of the first growth appear in the early spring, before the trees have developed new leaves. These plants die by the summer and are replaced by plants that grow in the shade of the leafy canopy.

The composition of individual temperate deciduous forests varies. For example, beech woods have a very poor herb layer, because of the dense shade that beech trees cast and because beech leaves are slow to *decompose* (rot) to produce *humus* (organic matter).

In Europe, temperate deciduous forests are the main forest type. The trees that make up the forests include ash, beech, elm, hornbeam, lime, oak, maple, and spindle. The more northerly forests may contain a mixture of deciduous and evergreen trees. The shrub layer is made up of elder, hawthorn, hazel, honeysuckle, and wild rose. Colourful plants of the herb layer include bluebells, primroses, and violets.

In North America, temperate deciduous forests are found from the Great Lakes south to the sandy coastal plains of Florida and Texas, where mixed pine and oak forests occur. The oldest and richest forests lie in the central Appalachian Mountains. Here, the dominant trees are ash, basswood (lime), beech, buckeye, cucumber magnolia, hickory, sugar maple, yellow poplar, and several kinds of oaks. Many trees are swathed in poison ivy and wild grape vines.

In Asia, temperate deciduous forests are found in the far east of Russia and in eastern China, Japan, and Korea. These broadleaf forests are extremely rich in both plant and animal life. The trees that make up the canopy layer include hornbeams, Korean pine, limes, Manchurian fir, maples, oaks, and walnuts. The understorey is made up of attractive shrubs, including deutzias, lilacs, and viburnums. Wild grape vines and woody lianas are also typical of these forests.

Deciduous forests have a rich animal life. The mammals include deer, dormice, the Eurasian badger, foxes, hedgehogs, racoons, shrews, squirrels, voles, and

weasels. Many of the smaller mammals hibernate during the winter. The birds include nuthatches, owls, titmice, treecreepers, warblers, and woodpeckers. The Asian mixed deciduous-evergreen forest contains many exotic mammals, such as forest cat, leopard, and tiger; and birds, such as the long-tailed Asian flycatcher and broad-billed roller.

Temperate evergreen forests are found in areas with a temperate climate, notably in western North America; western Chile; southeastern Australia and Tasmania; and New Zealand, especially the South Island. These forests all lie on steep slopes, where moist westerly winds rise up, producing high rainfall, or mist.

In North America, these forests are found in the north west, on the Pacific coast from Alaska south to northern California. Huge needleleaf trees dominate the Pacific coastal forests. Forests of redwood, one of the world's tallest trees, grow along a narrow coastal strip from southern Oregon to central California. Many of these giants grow more than 90 metres tall. Inland from the redwoods and farther to the north, grow magnificent forests of Douglas fir, Sitka spruce, western hemlock, and western red cedar. Along the coast of southern British Columbia and northern Washington, the high annual precipitation supports thick temperate rainforests. These forests, with their moss-covered Douglas fir, Sitka spruce, and Pacific red cedar, make up a damp, green wilderness found nowhere else in North America.

In Chile, the temperate evergreen forests are found between the Andes Mountains and the sea. The trees here are mainly southern beech, both deciduous and evergreen species, and conifers such as podocarps and the monkey-puzzle tree. The undergrowth is formed by evergreen shrubs, and the forest floor is rich in mosses, liverworts, and ferns.

The coastal forests of southeastern Australia and Tasmania are dominated by tall eucalyptus trees, such as mountain ash. Other eucalyptus trees include blue gum and blackbutt. Tree ferns are common understorey plants.

In the South Island of New Zealand, the forests are similar to those of Chile, with southern beech and podocarps, together with local conifers such as rimu and tanekaha. The New Zealand forests are home to a flightless bird called the kiwi.

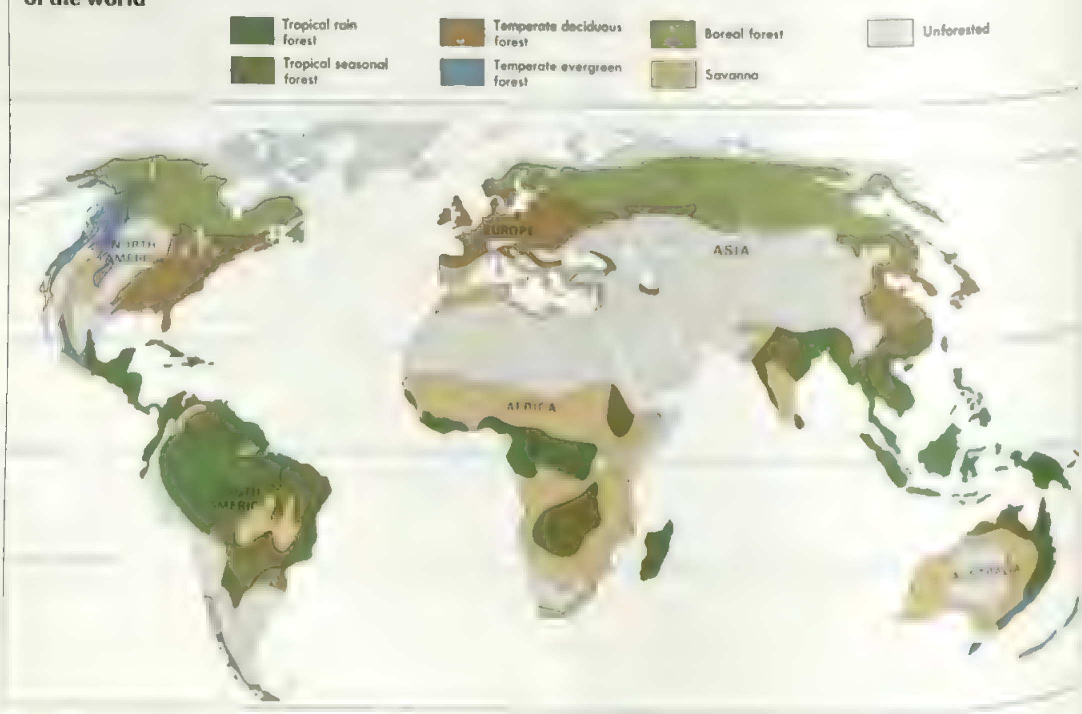
Mediterranean forests. The Mediterranean area has warm, moist winters and dry, hot summers. Mature forest is made up of broadleaf evergreen trees, such as evergreen oaks. These trees differ from deciduous oaks in having smaller, shiny leaves, of a leathery texture. Evergreen oaks do not shed all their leaves in the autumn. Rather, they continually shed and replace them throughout the year, like most needleleaf trees.

Because the Mediterranean region has been heavily populated for a long time, nearly all the original forests have been removed. Soil erosion and grazing by sheep and goats usually prevent their regrowth. Many forests have been turned into dense scrub, known locally as *chaparral, fynbos,* or *maquis.*

Other areas with this type of forest (or potential forest) are southern California, central Chile, South Africa, and southwestern Australia.

The laurel forests of the Canary Islands are unique, but only tiny remnants remain. They are broadleaf ever-

Natural forest regions of the world



green forests, like those of the Mediterranean, but the main trees are laurels rather than evergreen oaks.

The Mediterranean forest is rich in insects, particularly butterflies. It is also home to a wide range of snakes and lizards.

Tropical rainforests grow near the equator, where the climate is warm and wet all year round. The largest of these forests grow in the Amazon River Basin of South America, the Congo River Basin of Africa, and throughout much of Southeast Asia.

Of all the forest types, tropical rainforests have the greatest variety of trees. As many as 150 species may grow in a single hectare (100 metres by 100 metres) of forest. New species of plants and animals are still being discovered in this richest of the world's ecosystems. Unfortunately, these forests are being felled at an alarming rate.

Nearly all the trees of tropical rainforests are broadleaf evergreens, though palms and tree-ferns are also found. In most of the forests, the trees have three canopies. The upper canopy reaches about 40 metres high. A few exceptionally tall trees, called emergents, tower above the upper canopy. There is a second canopy at about 20 metres, and a lower canopy at about 10 metres.

The shrub and herb layers are thin because little sunlight penetrates the dense canopies. However, many climbing plants and epiphytes crowd the branches of the canopies, where the sunlight is fullest. Epiphytes called bromeliads trap water between their rosettes of leaves. These plants contain communities of small animals such as frogs, salamanders, and spiders.

Most animals of the tropical rainforests also live in the canopies, where they can find a plentiful food supply. These animals include bats, birds, lizards, monkeys, opossums, sloths, and snakes.

Tropical seasonal forests grow in certain regions of the tropics and subtropics. These regions have a definite wet and dry season each year or a somewhat cooler climate than that of the tropical rainforest. Such conditions occur in Central America, central South America, southern Africa, India, eastern China, northern Australia, and on many islands in the Pacific Ocean.

Tropical seasonal forests have a great variety of tree species, though not nearly as many as the rainforests. They also have fewer climbing plants and epiphytes. Unlike the trees of the rainforest, many tropical seasonal species are deciduous. The deciduous trees are found especially in regions with distinct wet and dry seasons. The trees shed their leaves in the dry season.

Tropical seasonal forests have a canopy at about 30 metres. One understorey grows beneath the canopy. Bamboos and palms form a dense shrub layer, and a thick herb layer blankets the ground. The animal life resembles that of the rainforest.

Savannas are areas of widely spaced trees. In some savannas, the trees grow in clumps. In others, individual trees grow throughout the area, forming an uneven, widely open canopy. In either case, most of the ground is covered by shrubs and herbs, especially grasses. As a result, some biologists classify savannas as grasslands. Savannas are found in regions where low rainfall, poor soil, frequent fires, or other factors limit tree growth.

Savanna woodland is found scattered throughout the monsoon belt of Africa, from Chad to Senegal, and in southern and eastern Africa. Trees include species of *Acacia* and *Brachystegia*.

Cerradao and *caatinga* are two kinds of dry, savanna-like woodlands found in South America. The trees that make up this woodland have a thick bark that is resistant to fire. There are also similar savanna-like woodlands in the monsoon areas of India. In Australia, the woods in the north have eucalyptus species, such as stringybark, and woollybutt. In the east, the commonest trees are brigalow.

The African savanna is famous for its rich mammal life. Mammals of the tropical savannas include elephants, gazelles, giraffes, and lions.

Mountain forests. On mountain ranges, in general the climate becomes cooler, wetter, and windier with increasing *altitude* (height). The types of vegetation, including forest, change as well. The forests of the lower and middle slopes are called *montane forests.* Those of the upper slopes are known as *subalpine forests.* In temperate regions, deciduous forest gives way to evergreen, needleleaf forest. In Europe, high mountain forests are usually dominated by spruce, and resemble some of the boreal forests. In Asia, species of spruce also form mountain forests, together with trees such as Siberian and Japanese stone pines. In North America, species of fir and pine are the main mountain forest trees. In the Rocky Mountains of North America, ponderosa pine and Douglas fir are the commonest trees, with Engelmann spruce and subalpine fir at higher altitudes. Other common North American mountain forest trees are white fir and lodgepole pine.

Mammals of mountain forests include bears, deer, and foxes. The puma inhabits the mountain forests of North, Central, and South America; the snow leopard, lives in mountain forests in Asia. In China, the giant panda lives in high-altitude bamboo forests.

Bamboo forests, which grow in tropical regions or in warmer temperate climates, are not true forests. The bamboo is a giant grass which can grow up to 40 metres (see **Bamboo**). However, where bamboo grows over an extensive area it is often described as forest and supports its own ecosystem.

The life of the forest

Forests are filled with an incredible variety of plant and animal life. For example, scientists recorded nearly 10,500 kinds of organisms in a deciduous forest in Switzerland. The number of individual plants and animals in a forest is enormous.

All life in a forest is part of a complex ecosystem, which also includes the physical environment. Ecologists study forest life by examining the ways in which the organisms interact with one another and with their environment. Such interactions involve (1) the flow of energy through the ecosystem, (2) the cycling of essential chemicals within the ecosystem, and (3) competition and cooperation among the organisms.

The flow of energy. All organisms need energy to stay alive. In forests, as in all other ecosystems, life depends on energy from the sun. However, only the green plants in the forest can use the sun's energy directly. Through a process called *photosynthesis,* they use sunlight to produce food.

All other forest organisms rely on green plants to

capture the energy of sunlight. Green plants are thus the *primary producers* in the forest. Animals that eat plants are known as *primary consumers* or *herbivores.* Animals that eat herbivores are called *secondary consumers* or *predators.* Secondary consumers themselves may fall prey to other predators, called *tertiary* (third) *consumers.* This series of primary producers and various levels of consumers is known as a *food chain.*

In a typical forest food chain, tree leaves (primary producers) are eaten by caterpillars (primary consumers). The caterpillars, in turn, are eaten by shrews (secondary consumers), which are then eaten by owls (tertiary consumers). Energy, in the form of food, passes from one level of the food chain to the next. But much energy is lost at each level. Therefore, a forest ecosystem can support, in terms of weight, far more green plants than herbivores and far more herbivores than predators.

The cycling of chemicals. All living things are made up of certain basic chemical elements. The supply of these chemicals is limited, and so they must be recycled for life to continue.

The *decomposers* of the forest floor play a vital role in chemical recycling. The decomposers include bacteria, earthworms, fungi, some insects, and certain single-celled organisms.

Decomposers obtain food by breaking down dead plants and the waste products and dead bodies of animals into their basic chemicals. The elements pass into the soil, where they are absorbed by the roots of growing plants. Without decomposition, the supply of such essential elements as nitrogen, phosphorus, and potassium would soon be exhausted.

Some chemical recycling does not involve decomposers. Green plants, for example, release oxygen during photosynthesis. Animals—and plants as well—need this chemical to *oxidize* (burn) food and so release energy. In the oxidation process, animals and plants give off carbon dioxide, which the green plants need for photosynthesis. Thus the cycling of oxygen and carbon dioxide works together and maintains a steady supply of the two chemicals.

Competition and cooperation. Every forest animal and plant must compete with individuals of its own and similar species for such necessities as nutrients, space, and water. For example, red squirrels in a boreal forest must compete with one another—and with certain other herbivores—for conifer seeds, their principal food. Similarly, conifers compete with one another and with other plants for water and sunlight. This competition helps ensure that the forest organisms best adapted to the environment will survive and reproduce.

Cooperation among the organisms of the forest is common. For many species, it is necessary for survival. For example, birds and mammals that eat fruit rely on plants for food. But the plants, in turn, may depend on these animals to help spread their seeds. Similarly, certain microscopic fungi grow on the roots of living trees. The fungi obtain food from the tree, but they also help the tree absorb needed water and nutrients.

For a diagram of a forest ecosystem, see **Ecology.**

How a forest develops

A forest develops through a series of changes in the kinds of plants and animals that live in an area. This process is called *ecological succession.* The pictures below show how a forest might develop and succession occur on abandoned farmland in the Southeastern United States.

A grassy meadow develops during the first few years. Pine seedlings appear throughout the meadow.

An evergreen forest gradually develops. Young pines need full sun, so deciduous trees form the understorey.

A deciduous-evergreen forest develops as the old pines die. Deciduous trees fill in the gaps in the canopy.

A wholly deciduous forest finally develops. This forest is the *climax* (final) stage in the succession.

Early forests

Forests evolved throughout the various periods of the earth's history. At the beginning of the Carboniferous Period – about 360 million years ago – tree-sized club mosses and horsetails were dominant forest plants. By the start of the Jurassic Period – about 215 million years ago – conifers had become widespread. During the Tertiary Period, which lasted from about 63 million to 5 million years ago, flowering broadleaf trees became common.

Carboniferous forest

Jurassic forest

Tertiary forest

Forest succession

In forests and other natural areas, a series of orderly changes may occur in the kinds of plants and animals that live in the area. This series of changes is called *ecological succession.* Areas undergoing succession pass through one or more *intermediate* stages until a final *climax* stage is reached. Forests exist in intermediate or climax stages of ecological succession in many places.

To illustrate how a forest develops and succession occurs, let us imagine an area of abandoned farmland in the Southeastern United States. The abandoned land will first support communities of low-growing weeds, insects, and mice. The land then gradually becomes a meadow as grasses and larger herbs and shrubs begin to appear. At the same time, rabbits, snakes, and ground-nesting birds begin to move into the area.

In a few years, young pine trees stand throughout the meadow. As the trees mature, the meadow becomes an intermediate forest of pines. The meadow herbs and shrubs die and are replaced by plants that grow better in the shade of the pine canopy. As the meadow plants disappear, so do the food chains based on them. New herbivores and predators enter the area, forming food chains based on the plant life of the pine forest.

Years pass, and the pines grow old and large. But few young pines grow beneath them because pine seedlings need direct sunlight. Instead, broadleaf trees – particularly oaks – form the understorey. As the old pines die, oaks fill the openings in the canopy. Gradually, a mixed deciduous-evergreen forest develops.

But the succession is still not complete. Young oaks grow well in the shade of the canopy, but pines do not. Therefore, a climax oak forest may eventually replace the mixed forest. However, in this region, pine wood is much more valuable than oak wood. For this reason, foresters sometimes use controlled fires to check the growth of oaks.

Different successional series occur in different areas. In southern boreal regions, for instance, pine, fir, and spruce dominate the climax forests. If fire, disease, or windstorms destroy one of the coniferous forests, an intermediate forest of aspen and birch may develop in its place. These deciduous trees grow better in direct sunlight and on bare ground than do fir and spruce.

The aspen-birch forest provides the protection young boreal conifers need, and soon spruce, fir, and pine seedlings make up most of the understorey. In time, these conifers grow taller than the aspen and birch trees. The deciduous species cannot reproduce in the shade of the new canopy, and gradually the climax forest of coniferous trees is reestablished.

The history of forests

The first forests developed in marshlands about 365 million years ago, toward the end of the Devonian Period. They consisted of tree-sized club mosses and ferns, some of which had trunks nearly 12 metres tall and about 1 metre thick. These forests became the home of early amphibians and insects.

By the beginning of the Carboniferous Period – about 360 million years ago – vast swamps developed. Forests of giant club mosses and horsetails up to about 40 metres tall grew in these warm swamps. Ferns about 3 metres tall formed a thick undergrowth that sheltered huge cockroaches, dragonflies, scorpions, and spiders. In time, seed ferns and primitive conifers developed in the swamp forests.

When plants of the swamp forests died, they fell into the water and mud that covered the forest floor. The

water and mud did not contain enough oxygen to support decomposers. As a result, the plants did not decay but became buried under layer after layer of mud. Over millions of years, the weight and pressure on the plants turned them into great coal deposits.

Later forests. As the Mesozoic Era began, about 240 million years ago, severe changes in climate and in the earth's surface wiped out the swamp forests. In the new, drier environment, gymnosperm trees became dominant. *Gymnosperms* are plants whose seeds are not enclosed in a fruit or seedcase. Such trees included seed ferns and primitive conifers. Gymnosperm trees formed forests that covered much of the earth. Amphibians, insects, and large reptiles lived in these forests.

The first flowering plants appeared about 130 million years ago, during the early Cretaceous Period. Flowering plants, or *angiosperms,* produce seeds enclosed in a fruit or seedcase. Many angiosperm trees became prominent in the forests. They included magnolias, maples, poplars, and willows. Flowering shrubs and herbs became common undergrowth plants.

At the start of the Cenozoic Era, about 63 million years ago, the earth's climate turned cooler. Magnificent temperate forests then spread across Europe, Asia and North America. The forests included a wealth of flowering broadleaf trees and needleleaf conifers.

Modern forests. The earth's climate continued to turn colder. By about 2.4 million years ago, the first of several great waves of glaciers had begun to advance over much of Europe, Asia and North America. By the time the last of these glaciers had retreated—about 10,000 years ago—the ice sheets had destroyed large areas of temperate forests in Europe and North America. The giant Amazon basin rainforest was reduced to a series of forest islands as the climate became drier. Only the temperate forests of Southeast Asia remained largely untouched.

The forests of the world took on their modern distribution after the glaciers had retreated. For example, the great boreal forests developed across northern Europe and North America. But the world's forest regions are not permanent. Today, for instance, temperate forests are invading the southern edge of the boreal region. Another ice age or global warming could have drastic consequences for the world's forests.

Deforestation

Human activities have had tremendous impact on modern forests. Since agriculture began about 11,000 years ago, large areas of forest have been cleared for farms and cities. During the 1800's and 1900's, great expanses of forests have been eliminated because of logging activities and industrial pollution. The destruction of forests is called deforestation.

Today, severe deforestation occurs in tropical areas, primarily as a result of the clearing of land for agriculture. Until the late 1940's, tropical rainforests covered about 16 million square kilometres of the earth's land. In the early 1990's, they covered only about 8 million square kilometres. About 170,000 square kilometres of tropical rainforests are destroyed each year, mostly in Latin America and Southeast Asia.

Rapid forest destruction is often a symptom of social unrest. Large numbers of poor, landless families move into the forests and clear the trees in order to grow crops. Civil war can also pose a threat to the forests, as trees are felled to provide fast cash with which to buy armaments. More forests, especially in savanna regions, are stripped to provide wood for fuel, often for the nearby cities. Also, the commercial timber industry is important, especially in parts of Southeast Asia, where trees are felled for export.

In the temperate lands of North America and Europe, planting policies have ensured that there is more tree cover at the end of the 1900's than there was at the beginning of the 1900's. The exceptions are areas such as eastern and central Europe. Forests in these areas have been damaged by air pollution in the form of acid rain (see **Acid rain**). Acid rain can restrict plant growth and eventually kill trees and plants.

The destruction of forests has potentially far-reaching effects on the planet. As trees are burned or rot, they release carbon dioxide into the atmosphere. This contributes to global warming and the greenhouse effect (see **Greenhouse effect**). The fewer trees there are, the less ability the earth has to absorb carbon dioxide in the air. The loss of tropical rainforests threatens the survival of a great many of the world's plant and animal species.

Related articles in ***World Book***. See **Tree** and its list of *Related articles*. See also the *Economy* section of the various country articles. Other related articles include:

Conservation	Forestry	Tropical rainforest
Ecology	Jungle	
Forest products	Petrified forest	

Outline

I. The importance of forests
- A. Economic value
- B. Environmental value
- C. Value for culture and recreation

II. The structure of forests
- A. The canopy
- B. The understorey
- C. The shrub layer
- D. The herb layer
- E. The forest floor

III. Kinds of forests
- A. Boreal forests
- B. Temperate deciduous forests
- C. Temperate evergreen forests
- D. Mediterranean forests
- E. Tropical rainforests
- F. Tropical seasonal forests
- G. Savannas
- H. Mountain forests
- I. Bamboo forests

IV. The life of the forest
- A. The flow of energy
- B. The cycling of chemicals
- C. Competition and cooperation

V. Forest succession

VI. The history of forests

VII. Deforestation

Questions

How do forests help conserve and enrich the environment?
How does an *intermediate* forest differ from a *climax* forest?
Which layer of the forest produces the most food? Why?
Where do forests of the world's bulkiest trees grow? What are these trees?
When did the first forests develop?
How do deciduous and evergreen forests differ?
How does the forest food chain work?
Which kind of forest has the greatest variety of trees?

Forest conservation. See **Conservation** (Forest conservation); **Forestry.**

Forest fire. See **Forestry** (Fire).

Forest Heath (pop. 57,200), a local government district in Suffolk, England, includes the famous horse-racing town of Newmarket. Forest Heath also includes Brandon, Icklingham, and Mildenhall. A large part of Thetford Chase forest lies within the district. Local industries include agriculture, forestry, horse racing, light engineering, and the manufacture of electronic goods, pharmaceuticals, and plastics.

See also **Suffolk.**

Forest of Dean (pop. 74,200) is a local government district in western Gloucestershire, England, which includes the Forest of Dean National Forest Park. The district has large areas of beautiful woodlands and also includes part of the Wye Valley in the west and Malvern Hills in the north.

The main towns in the district are Cinderford, Lydney, and Newent. Local industries include coal mining, forestry, light engineering, and mixed farming, and the making of car accessories, clothing, and plastics goods.

See also **Gloucestershire.**

Forest products have long provided people with food, shelter, clothing, and fuel. Prehistoric people ate berries and nuts that grew in forests. They built shelters from the branches of trees and wore clothing made of plant materials. About $1\frac{1}{2}$ million years ago, they began using wood as a fuel to make fire.

Today, wood is one of our most important raw materials. It is used in making thousands of products, from building materials to plastics and photographic film. Wood is the source of paper for books, newspapers, and packaging materials. In many countries, houses are built of wood. Despite its usefulness as a raw material for processing, however, the chief use of wood throughout the world is as a fuel.

There are thousands of forest products. Most can be classified into one of four main groups: (1) wood products, (2) fibre products, (3) chemical products, and (4) fuel products. Wood products are made from solid wood or from pieces that are large enough to be readily identified as wood. Fibre products such as paper are made from wood fibres. Chemical products are manufactured by breaking down wood and wood fibres and chemically treating them. Such chemical products as cellophane, lacquer, and rayon do not feel or look like wood. But all are made from it. Fuel products include logs, wood pellets, and charcoal. Other forest products come from the bark, fruit, gum, leaves, and sap of trees.

This article describes different forest products. For information about logging, see **Timber.**

Wood products

Wood has many characteristics that make it an important construction material. It can be easily shaped with tools and fastened with nails, screws, staples, and adhesives. It is light but strong. Wood provides insulation against electricity, heat, cold, and sound. It can hold paint and other finishes, and it does not rust. Unlike metal construction materials, wood is a *renewable resource*—that is, a new supply grows after the timber

Some uses of forest products

Wood products

Timber
- Barrels
- Boats
- Bowling pins
- Boxes
- Cabinets
- Coffins
- Crates
- Cricket bats
- Doors
- Fencing
- Flooring
- Furniture
- Laminated beams
- Mine timbers
- Moulding
- Musical instruments
- Panelling
- Pencils
- Railway sleepers
- Shingles
- Structural timber
- Window frames

Particle board
- Cabinet tops
- Doors
- Drawer sides
- Floor underlay
- Furniture
- Panelling
- Roof decking
- Sheathing
- Weatherboard

Plywood
- Aeroplanes
- Boats
- Concrete forms
- Containers
- Floor underlay
- Furniture
- House foundations
- Panelling
- Roof decking
- Sheathing
- Structural beams
- Weatherboard

Round timbers
- Bridges
- Fence posts
- Log homes
- Piles
- Utility poles

Veneer products
- Baskets
- Boxes
- Cabinets
- Furniture
- Matches
- Panelling
- Tongue depressors
- Toothpicks

Fibre products

Hardboard
- Cabinets
- Car interiors
- Furniture
- Garage doors
- Panelling
- Siding
- Signs

Insulation board
- Ceiling tiles
- Sheathing

Paper and paperboard
- Bags
- Books
- Cartons
- Newspaper
- Packaging
- Tissue

Chemical products

Cellulose products
- Acetate
- Adhesives
- Cellophane
- Ceramics
- Detergent additives
- Lacquers
- Photographic film
- Plastics
- Rayon
- Tyre cords

Lignin products
- Animal feeds
- Artificial vanilla
- Ceramics
- Cement
- Dyes
- Plastics
- Printing inks
- Textile binder

Naval stores
- Adhesives
- Cleaners
- Disinfectants
- Linoleum flooring
- Lubricants
- Printing inks
- Rosin
- Synthetic rubber
- Turpentine
- Varnishes

Fuel products
- Charcoal
- Fireplace logs
- Pulverized fuel
- Sawdust
- Wood chips

Other forest products

Bamboo and rattan
- Baskets
- Fencing
- Furniture
- Roofing

Bark
- Adhesives
- Cork
- Dyes
- Fuel
- Soil mulch
- Tannic acid

Fruit and seeds
- Beechnuts
- Blueberries
- Cranberries
- Kapok
- Palm hearts
- Pecans
- Pine nuts
- Walnuts

Gum and sap
- Maple sugar
- Maple syrup
- Pine oil
- Rosin
- Tall oil
- Turpentine

Leaves
- Fertilizer
- Medicine
- Perfumes
- Soap

has been harvested provided the forest is properly managed. Some of the chief wood structural materials are round timbers, timber, plywood, veneer products, and particle board or chipboard.

Round timbers include pilings, poles, and posts. Pilings are driven into the ground as foundations for buildings, wharves, and other heavy structures. Poles link overhead telephone wires and power lines. Posts are used chiefly to build fences. Round timbers are simply trees that have been stripped of their branches and bark, and cut into logs. The logs are dried and treated for protection against decay and insect attack.

Timber includes boards and larger pieces of wood sawed from logs. The construction industry is the largest single user of timber. The rest is used in making crates, furniture, railway sleepers, sporting goods, toys, and thousands of other products. See **Timber**.

Wood scientists classify timber as *softwood* or *hardwood,* depending on the kind of tree. This classification does not always indicate the hardness of the wood. Various softwoods produce harder timber than do some hardwoods. Softwood timber comes from needleleaf trees, which are also called *conifers* or *evergreens.* It is used primarily for structural work because of its straightness and length. Softwoods include pine, fir, hemlock, redwood, cypress, cedar, and Douglas-fir.

Hardwood timber comes from trees that have broad leaves. Many hardwoods are known for their beautiful grain patterns. For this reason, they are widely used for cabinets, flooring, furniture, and panelling. Popular hardwoods include beech, elm, oak, teak, sweet gum, walnut, fruit woods such as cherry, and mahogany.

Plywood consists of a number of thin sheets of wood called *veneers* that are glued together. The veneers are arranged so that the grain direction in each layer is at a right angle to the grain direction of the next layer. This arrangement gives plywood several advantages over timber. Plywood shrinks, swells, and warps less than

Leading countries in forest products

Figures are for 1992. Source: *Yearbook of Forest Products,* 1992. Food and Agriculture Organization of the United Nations.

timber, and it can be easily nailed near the edges without splitting. A very thin veneer of expensive hardwood can be applied to a core of less expensive wood, producing plywood that has the look of expensive wood but not the cost. Plywood and veneers are widely used in the construction and furniture industries.

Veneer products are made of thin veneers. These veneers may be cut into long strips or other shapes. Veneer products include beams that support ceilings and floors, matches, and toothpicks.

Particle board, also called *chipboard,* is made from wood shavings, flakes, wafers, splinters, or sawdust left over in sawmills and paper mills. This wood is mixed with an adhesive and pressed at a high temperature and pressure to form large sheets or panels. Particle board shrinks and swells very little in length and width. It may be used as a base for flooring and furniture. Some particle board has the strength of plywood and many of the same uses.

Fibre products

Wood is made up of many tiny fibres. Manufacturers produce paper and paperboard, hardboard, and insulation board from wood fibres. Wood fibre is also used as attic insulation, as a protective soil covering called *mulch,* and even as a dietary fibre in breakfast cereals.

Paper and paperboard are made from wood chips reduced to a fibre pulp by chemicals, heat, or other treatment. The pulp is then formed into a mat, filtered, drained, and pressed. Paper products include bags, books, packaging materials, stationery, and tissue.

Hardboard is manufactured by pressing wood fibres into flat sheets at a high temperature and pressure. Hardboard is used chiefly in furniture and panelling.

Insulation board is manufactured from wood fibres that are formed into a mat, pressed lightly, and dried. It weighs less than hardboard. Insulation board is used for acoustic tiles and in building construction.

Chemical products

Many wood products are made from wood or bark that has been broken down into such basic chemical parts as cellulose and lignin. Cellulose is the main ingredient of wood fibres. Lignin, found in and between wood fibres, holds the fibres together.

Cellulose products. Cellulose may be chemically treated to change its properties and to produce such compounds as *cellulose acetate* and *cellulose nitrate.* Both of these compounds are used in adhesives, lacquers, and plastics. Plastic items moulded from cellulose compounds include piano keys, tool handles, and table tennis balls. Cellulose nitrate is also an ingredient in explosives. Other cellulose compounds have specialized uses in such products as paint, foods, and textiles.

Manufacturers process cellulose to produce rayon and acetate fibres, which are used for clothing, curtains and upholstery. Rayon cords strengthen tyres. Other materials made from cellulose include cellophane and photographic film. See **Cellulose; Rayon.**

Lignin products. Lignin has far fewer uses than cellulose. It is used in making printing inks, dyes, and concrete. Manufacturers use it to *bind* (hold together) animal food pellets and textiles. Artificial vanilla is used as a flavouring in many foods. It also is made from lignin.

Plywood, *left,* is a widely used wood product. Workers in this manufacturing plant are stacking finished pieces of plywood

Naval stores include turpentine and rosin—materials once essential to the operation of wooden sailing ships. Almost all naval stores come from the processing of pine pulp.

Fuel products

In many developing countries, wood has long served as the primary fuel for cooking and heating. However, in the face of growing populations and widespread *deforestation* (woodland clearance), fuelwood supplies are rapidly running out. People have to go further afield to collect fuel, so fewer meals may be cooked, and the consumption of raw, or inadequately cooked food may become a health hazard.

In industrial countries, wood has been burned mainly in fireplaces and charcoal grills. After petroleum prices rose in the 1970's, wood became a more popular fuel in communities near forested areas. Fuel products made from wood include split, dried logs; compressed wood pellets; charcoal; and sawmill by-products. In addition, the forest products industry burns the thick liquid that results from pulping wood.

Other forest products

Forest products are made from the bark, fruit, gum, leaves, sap, and seeds of trees, as well as the wood. By-products from sawmills include wood chips, shavings, and sawdust. These by-products are used in making particle board and other products, animal bedding, and floor-sweeping compounds.

The bark from the cork oak tree provides cork for such products as bottle stoppers, bulletin boards, and insulation. The bark of the hemlock and other trees furnishes tannic acid used in processing animal hides. Bark is sometimes used as fuel, ground cover, or mulch.

Fruit and seeds harvested from forest trees include many kinds of nuts. The seedpods of the kapok tree provide fibres, used as a filler in sleeping bags.

Latex is a milky substance produced by plants and trees of the sapodilla family. Latex is the source of natural rubber, which is used to make balloons, hoses, tyres, and other items.

The leaves of certain conifers and eucalyptus species are distilled to produce oil used in perfumes, household cleaners, soaps, and drugs. Sap from certain kinds of maple trees is made into maple syrup and maple sugar.

The forest products industry

The manufacture or processing of forest products in industrial countries is very extensive. The United States, the world's largest producer of forest products, uses about 370 million metric tons of wood a year. Throughout the world, small-scale industrial concerns employing fewer than five people, provide most of the jobs in the forestry industries. In some developing countries, such as India, millions of tribal and landless people depend on gathering and selling forest products for cash to buy food and other necessities. In northeastern Brazil, millions of people rely on cash from collecting the kernels of the babassu palm. Some governments and forestry businesses are developing methods to increase the yield of the many commodities that forests can provide in addition to timber. The methods, geared to harvesting more than one product, are called *multiple product forestry.* There is also a growing market in the industrial world for products that are marketed as coming from the rainforest. Cosmetics and ice cream are two examples.

Related articles in *World Book.* See **Wood** and its list of *Related articles.* See also the following articles:

Bark	Gum	Resin	Tar
Charcoal	Lacquer	Rosin	Timber
Cork	Naval stores	Rubber	Turpentine
Creosote	Paper	Sap	Veneer
Fibreboard	Rayon	Tannic acid	

Forest ranger. See **Forestry.**

Forester, Cecil Scott (1899-1966), was an English novelist who won fame for his fictional creation of Horatio Hornblower, a British naval hero of the 1800's. Hornblower's exciting adventures, his coolness and inventiveness under stress, and his weakness for women endeared him to a large reading public. Hornblower rises from midshipman to admiral in a series of novels that includes *Beat to Quarters* (1937), *Flying Colours* (1938), *A Ship of the Line* (1939), and *Lord Hornblower* (1946). Forester's adventure novel *The African Queen* (1935) was made into a popular film in 1951.

Forester believed his other novels, especially *The General* (1936), were equal to the Hornblower books. But his readers overwhelmingly favoured the naval hero. Forester was born in Cairo, and educated in England. He lived in the United States from 1945 until his death.

Forestry is the scientific management of forests, planting and caring for trees, and the maintenance of forest resources, such as water, wild life, and recreation areas

Forestry

Forestry is the science of managing forest resources for human benefit. The practice of good forestry helps maintain an adequate supply of timber for the manufacture of plywood, paper, and other wood products. It also includes the management of such resources as water, wildlife, grazing areas, and recreation areas.

In general, forests provide the greatest benefits when they are managed with the goal of providing several benefits at once. This concept, called *multiple use forest management,* is applied in many forests. Forests can provide water for communities; food and shelter for wildlife; and recreation areas for campers, hikers, and picnickers. In some forests, however, the importance of one resource may outweigh that of others. For example, companies that manufacture wood products manage their forests primarily for maximum timber production.

This article discusses the scientific management of forest resources. For information on the various products made from trees, see **Forest products.** For a discussion of forest ecology, see **Forest.**

Managing timber resources

The goal of managing timber resources is to achieve an approximate balance between the annual harvest and growth of wood. This balance, called a *sustained yield,* ensures a continuous supply of timber. It is achieved by managing forests so they have areas of trees of equal yield for each age group, from seedlings to mature trees. The science of cultivating trees for sustained yield is called *silviculture.* The practice of silviculture requires that foresters know how various species of trees grow in different climates and soils, and how much sunlight and water the trees need. Foresters also use the science of genetics to breed trees that have improved growth rates and greater resistance to diseases and pests.

Harvesting. There are four chief methods of harvesting timber: (1) clear felling, (2) seed tree felling, (3) shelterwood felling, and (4) group felling. Each *felling* (cutting) method is also a way of replacing the crop. New trees grow from seeds produced by the remaining or surrounding trees, from sprouting stumps, or from seeds or seedlings that foresters plant.

Clear felling is the removal of all the trees in a certain area of a forest. Clear felled areas range in size from a few hectares to 50 hectares or more. The areas must be large enough to prevent surrounding forests from affecting them. Clear felling is generally used to reestablish a *stand* (large group of trees) that is more even in age, by removing a mature one. It is also the method generally used when a forest is to be replaced by planting or by sprouting stumps, or when the forest is to be cleared permanently. This method is often used in the tropics, but it can damage the soil. Heavy machinery compacts the soil and rainfall erodes newly cleared land, making new growth unlikely.

Seed tree felling resembles clear felling, but foresters leave a few trees widely scattered in the harvested area to provide a natural source of seeds. These seed trees are removed after the new stand is established. Seed tree felling is often used with varieties of pine.

Shelterwood felling involves harvesting timber in several stages over a period of 10 to 20 years. Foresters establish a new stand as the old one is removed. Shelterwood felling can be used with broadleaf trees such as oak, and pines, which require shade during their first few years of growth. It also allows the growth of some trees in a stand to continue after the majority of the trees have ceased growing well.

Group felling is the harvesting of small patches of mature trees to make room for younger trees and new

growth. The trees are removed on the basis of their size and nearness to other trees. However, foresters leave many larger trees standing to produce seeds. Group felling leaves only small openings in a forest, and so it works best with trees that grow well in shade. Forests may be harvested by group felling every 5 to 30 years.

Planting. Foresters plant new timber crops by a process called *artificial reforestation.* They either plant seeds directly in the harvested land, or they raise seedlings in a nursery and transplant these young trees in the forest. The process is called *afforestation* when these methods are used to plant trees on land that was never covered by a forest.

Direct seeding works best on cultivated land or on land where a timber crop has been destroyed by fire. The seeds may be treated with a chemical repellent, which discourages animals from eating them, and they are sown between late autumn and early spring. Aeroplanes or helicopters are sometimes used to scatter the seeds, but seeds may also be placed in the ground with hand tools. About 75,000 seeds per hectare are usually sown to ensure an adequate crop of trees.

Outside the tropics, seedlings are planted in late winter or early spring, before the buds of the seedlings have opened for the growing season. Seedlings grow in a nursery for a period of one to four years before being transplanted to the forest. Foresters generally plant approximately 2,000 trees per hectare, using hand tools or various kinds of planting machines. A person can plant approximately 0.4 hectare a day by hand—about as much land as a machine can plant in an hour.

Tree improvement involves breeding trees for superior growth rates and increased resistance to diseases and pests. Foresters begin this process by searching forests for the straightest and fastest-growing trees of the species. Such trees, sometimes called *supertrees,* must also have high-quality wood and be healthy and free of harmful insects and other pests.

After foresters find a superior tree, they take cuttings, called *scions,* from its branches. The scions are brought to a nursery and *grafted* (joined) to the roots of 2-year-old trees (see **Grafting**). The scions receive nutrients through the roots of the young trees but keep the characteristics of the tree from which they were cut. Foresters then take pollen from the male flowers or cones of the scions and pollinate the female flowers or cones of scions from other superior trees. The foresters keep careful records of the scions used for each pollination.

After pollination, the female flowers or cones produce seeds, which are planted in the nursery and grown into seedlings. Foresters transplant the seedlings into special plantations and closely measure the growth of the trees. If the trees from a particular set of parents appear to be developing into supertrees, the seeds from those parents may be produced commercially and used for reforestation.

Managing other forest resources

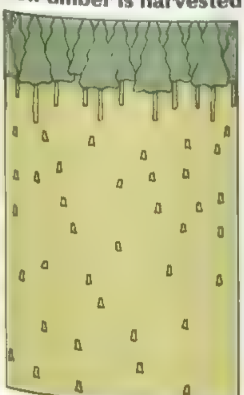
Water. Nearly all forests serve as *watersheds* (sources of water for rivers and streams). The soil of forests collects water by soaking up rain and melted snow. Watershed management largely involves keeping the forest soil porous so it can absorb a maximum amount of water.

The soil of a forest is covered by a spongy layer of leaves and twigs, called *litter.* The action of earthworms, insects, rodents, and decaying roots creates spaces within the soil. When rain or snow falls, the water is absorbed by the litter and these spaces in the soil. Much of the water is used by plants, and some flows underground and then into rivers, streams, and wells. If forest soil becomes too hard and nonporous, water flows over the surface of the ground, carrying mud and other materials into nearby streams. This runoff damages other soil, pollutes the water of the streams, and may even cause flooding.

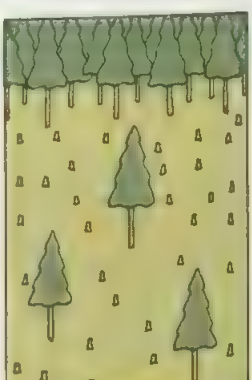
Foresters help keep soil porous in several ways. They plant trees or shrubs in open areas in the forest to ensure a continuous supply of litter. They regulate livestock grazing to maintain a good cover of grass and to prevent the animals from packing down the earth. Foresters also make sure that truck roads built for logging operations are carefully designed to prevent damage to the soil.

Control of runoff water is one of the biggest problems in many forests especially in mountainous regions.

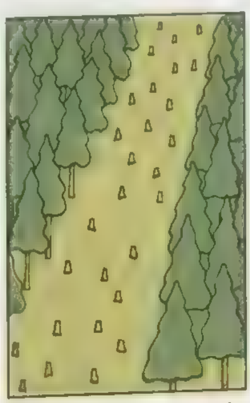
How timber is harvested



Clear felling removes all the trees in a large area. It provides full sunlight in which new seedlings can develop.



Seed tree felling leaves a few scattered trees in the area to provide a source of seeds for a new crop.



Shelterwood felling, which is used for trees that require shade to develop, removes trees in several stages.

Group felling involves harvesting small patches of mature trees to make room for new and younger trees.

Surplus water has to be drained and channelled, while ensuring that the forest soil remains porous.

Wildlife. Forests provide homes for a wide variety of wildlife, including birds, deer, fish, rodents, and snakes. Wildlife management involves maintaining a balance between the number of animals in a forest and the supply of food, water, and shelter

Forests that consist of a mixture of young and old trees generally support the greatest variety of wildlife. Dense forests of old, tall trees provide good homes for birds, insects, and such climbing mammals as squirrels. But the shade in such forests prevents the growth of enough herbs, shrubs, and small trees to feed deer and other large animals that live on the ground. However, openings made in the forest during the timber harvest allow more sunlight to reach the forest floor. Hollow trees may also be left in large openings to serve as dens and nesting places. New plants soon begin to sprout in the clearings, providing food for wildlife. The animals tend to feed along the edges of the clearings, near the protective cover of the trees.

Wildlife management also involves controlling animal populations by regulating hunting. During food shortages caused by overpopulation of wildlife, animals may damage trees by feeding on bark, buds, and twigs.

Community forestry is a system of forest management that treats woodlands as a communal resource. In northern temperate countries, such as those of northwestern Europe and parts of North America, forests have been set aside for communal use since the 1600's. But in developing countries, community forestry is still relatively new. In these countries, poor rural communities have learned to practise this form of forestry management as a means of providing themselves with fuelwood and increasing their food supply and income. Unfortunately, the supply of forest products is rapidly dwindling as forests decline and the populations of developing countries increase.

Community forestry takes many forms. In *village woodlots,* trees are grown for firewood on any spare patches of land. In *intercropping,* or *agroforestry,* cereals, vegetables, and fruit are grown between rows of newly planted trees until the trees grow too tall and overshadow them. *Silvipasture* involves managing tree growth through controlled forest grazing by animals. *Multiple-product forestry* is a set of techniques for increasing the yield of fruit, game, honey, and other commodities apart from timber, provided by forests.

Artificial reforestation involves planting new trees in bare areas. This forester is planting pine seedlings in an area where trees were burned out in a forest fire.

A forester strips branches and bark from felled trees so that the debris left behind can *decompose* (rot) and thereby enrich the soil of the forest floor.

Recreation areas. The scenic beauty and natural resources of forests provide opportunities for many recreational activities, including camping, hiking, fishing, and hunting. Millions of people visit forests annually. Many forest products companies also open areas of their woodlands for the public to use, chiefly for hunting and fishing.

Protecting forest resources

The full benefits of forest resources can be obtained only if timber is protected from fires, diseases, and insect pests. Fire is a great threat to forests, but it is also a natural feature of all but the wettest forests. Natural fires are an important way for old trees and undergrowth to be cleared to make way for new growth. Modern forestry practice therefore attempts to control fires rather than eliminate them. However, the largest number of forest fires are caused by people. People start many fires by carelessly dropping lighted cigarettes, or by leaving behind glass bottles, which can act as a "burning glass". Other forest fires are set deliberately. Forest fires can best be prevented by educating people to understand the value of forests and the importance of protecting them. During dry seasons, when fires can easily start, foresters may close a forest to the public to reduce the danger of fire.

Foresters may watch for fires from lookout towers in a forest. These towers have binoculars, direction find-

ers, and other equipment to locate fires, and a telephone or short-wave radio to call fire fighters to a burning area. However, many lookout towers have been replaced by aeroplane patrols.

Forest fires feed on fallen leaves, twigs, and other decaying material on the forest floor. The task of extinguishing a forest fire largely involves removing this blanket of fuel. Fire-fighting crews spray water or chemicals on the burning area to cool the fire and slow its progress. They then can get close enough to the flames to dig a *firebreak*. A firebreak is a strip of land between two stands of trees that is cleared to create an obstacle to the spread of the flames. The fire fighters start a firebreak by clearing all brush, logs, and trees from a wide strip around the fire. Then they scrape away the litter and some of the soil with axes, shovels, or bulldozers.

After creating a firebreak, the fire fighters may set *backfires* to burn the area between the line and the forest fire itself. Backfires remove additional fuel and widen the firebreak to help stop the spread of the flames. After a fire dies, the fire fighters clear any flammable material from the edge of the burned area. This action prevents the material from smouldering and starting new fires.

Fire is sometimes used as a tool to benefit the forest. In a process called *prescribed burning,* foresters may set small fires in the litter on the forest floor to reduce the potential fuel for a fire. Prescribed burning also kills diseases, insect pests, and the seedlings of unwanted trees. This technique must be used with extreme care.

Diseases and pests. Most tree diseases are caused by fungus infections. Diseases attack trees chiefly by clogging the flow of sap, killing the leaves, or rotting the roots or wood. Some of the most destructive diseases include beech bark disease, chestnut blight, Dutch elm disease, oak wilt, and stem blister rusts that affect pines.

Insects that damage trees include bark beetles, sucking insects, and *defoliators*. Bark beetles feed on a tree's inner bark. Sucking insects suck the fluid from trees. Defoliators eat leaves. Various kinds of bark beetles destroy millions of evergreens yearly. Defoliators, which include spruce budworms and tussock moths, also attack evergreens. One defoliator, the gypsy moth, is especially harmful to oak trees. Sucking insects, such as aphids and scales, feed on all types of trees

Foresters control diseases and pests by three chief methods: (1) biological controls, (2) silvicultural controls, and (3) direct controls. Biological controls fight diseases and pests with natural enemies. For example, foresters might increase the number of birds in a forest to reduce the insect population Silvicultural controls use methods of timber management to make a forest undesirable for diseases and pests. Foresters follow such silvicultural practices as removing old, weak trees that are easy prey for fungi and insects. Direct controls include the use of chemical pesticides to kill fungi and insects. The chemicals can upset the ecological balance of a forest, and so pesticides are generally used only if other controls fail to stop pests and diseases.

History

People have used forest products for thousands of years. Prehistoric people of the Old Stone Age lived in or near natural forests. There they hunted animals for food and used the wood as fuel and for making tools and weapons. Middle Stone Age people cut down trees with flint axes to make clearings in which to build camps and plant crops. Later, they used timber to build houses and boats. From the New Stone Age onward, farmers cut down much natural woodland to open up land for agriculture.

People probably learned to grow trees from seeds or cuttings in the Middle East several thousand years ago. The ancient Romans imported trees into the Mediterranean region and European countries, especially Germany. They were also interested in tree conservation and planted many groves of trees for religious and recreational reasons. After the Roman Empire fell, uncontrolled tree felling led to soil erosion and the silting of some waterways. Medieval forestry laws aimed to ensure that there was sufficient game for the nobility to hunt. For this reason, areas of natural forest were preserved along with their deer and other wildlife. Peasants

A forest campground may provide cooking facilities, electrical outlets, and plumbing. Foresters plan recreation areas to meet the needs of campers without harming the environment.

Fighting a forest fire involves removing the fuel from the path of the flames. Fire fighters may clear leaves, wood, and other material from the forest floor with axes and shovels, *above*.

who broke the law suffered harsh penalties. In some areas, monks cultivated small forest plantations.

A systematic and scientific approach to forest management developed in the 1500's. People in some German states began setting aside parts of forest plantations for timber cutting and other parts for growing new trees to replace the ones being used up. Management of forests on a sustained-yield basis soon developed throughout Europe. In the 1800's, the first colleges teaching forestry subjects opened in France and Germany.

In North America, the early settlers treated the vast timber resources they found there as if they would last for ever. Using inefficient logging techniques, the settlers cleared much more forest land than they needed for their houses and crops. In the 1800's, United States forestry experts, who were trained in Europe, called for planned forest management. The 1900's saw the start of industrial forestry programmes and the passage of many laws protecting forests and their wildlife and recognizing their importance to the world's environment and climate.

Malaysia's first rubber trees were planted in the 1870's. Plantations developed, and now about 85 per cent of the world's natural rubber is produced in Malaysia and Indonesia. A variety of other products come from local natural rainforests.

During the 1900's, in the Soviet Union and China, all forests became state-owned. In the United States and Canada, a large part of the 700 million hectares of forests is owned by national and local governments. The U.S. and Canadian Forestry services, along with many voluntary organizations, manage many of these forests. There are also privately and commercially owned forests. In Britain, about 60 per cent of the 2 million hectares of forests are privately or commercially owned, and the rest are managed on behalf of the state by the Forestry Commission, a government agency. In Northern Ireland, the state forestry agency is the Department of Agriculture.

In Australia, native forests cover about 100 million hectares and account for about three-fourths of the country's timber production. Plantations of fast-growing pines, which are native to Central and North America, have been established since the 1930's. Nearly three-fourths of the 750,000 hectares of forest plantations in Australia are state-owned and managed by the Australian Forestry Council.

New Zealand has 7 million hectares of forest, 88 per cent of which is natural forest located in remote, mountainous areas. There the trees protect the land against soil erosion by heavy rain. New Zealand's timber comes from commercial and state-run plantations of *exotic* (non-native) pines.

In India, about 375 million hectares of land are forested. This is all that remains of a once dense woodland that covered most of India. India's forests produce such woods as sal, sandalwood, and teak. The selling of sandalwood is strictly controlled by the state. Much of India's forest is located in the foothills of the Himalaya, but coconut and palmyra palms are important on the west coast and in the south.

Most countries with forests have state forestry authorities, which manage woodlands and conduct research. In Africa, however, many forests are owned by local tribes.

By the late 1980's, people had finally begun to realize the importance of forests to the environment. In India, soil erosion had been caused by cutting down forests to grow cash crops, in a process known as *shifting cultivation*. In the Himalayan foothills, this process was the cause of disastrous flooding. Removal of sections of African rainforest had led to desertification and drought. In Latin America, where forest covers 942 million hectares, or 46 per cent of the land area, burning of the rainforest to open up agricultural land seemed likely to disturb the world's climate and increase the greenhouse effect (see **Greenhouse effect**). Yet many countries still had to balance the need to protect the environment with the need to grow food and provide fuel for heating and cooking.

Related articles in *World Book.* See Forest and Forest products and their lists of *Related articles.* See also:

Aphid	Gypsy moth	Tussock moth
Conservation	Nursery	Wildlife conservation
Dutch elm disease	Scale insect	
	Tree farming	

Forfeiture is a legal punishment or penalty by which a person who is guilty of wrongdoing or who has breached a contract or condition loses some right or possession. People who drive too fast may have their licences taken away and thus *forfeit* the right to drive. A corporation may forfeit its charter if it abuses its privileges. Ordinarily, forfeitures of this type can be made only by court action or by administrative action which is later subject to review by a court. Forfeiture may occur when a person fails to perform certain duties required under a contract or lease. For example, if a person fails to make payment for a car purchased on credit, he or she may forfeit ownership of the car.

Forge. See **Forging** (Hand forging; picture); **Blacksmith.**

Forgery is deliberately tampering with a written paper for the purpose of deceit or fraud. Common kinds of forgery include fraudulently signing another person's name on a cheque or document, changing the figures on a cheque to alter its amount, and making changes in a will or contract. The punishment for forgery is usually imprisonment. Intent to defraud must be proved before a person can be convicted of forgery. Literary forgers have tried to pass off forged documents as rare manuscripts.

Forget-me-not is a plant that belongs to the borage family. It grows in both wild and cultivated forms in temperate regions. Many forget-me-nots have hairy stems and soft, hairy leaves. The small flowers are light-blue with yellow centres and grow in clusters. Several kinds of forget-me-nots have white or pink flowers. Almost all kinds have pink flower buds.

Most forget-me-nots grow best in shady, moist places. The water forget-me-not is an attractive *perennial* (plant that lives for more than one year) with pale blue, yellow-eyed flowers. The most popular garden kinds are *biennials,* plants that flower in their second year. They are grown by breaking up clumps of existing plants and transplanting them. Several common varieties of forget-me-nots are *annuals* that live for only one year. They are grown from seed and bloom in autumn.

The forget-me-not is a symbol of friendship and of true love. The flower appears in many legends. In German legend, *forget me not* were the last words a lover spoke before he drowned trying to get the flower for his sweetheart. According to another legend, all the plants and animals shrank away from Adam and Eve when the two were expelled from the Garden of Eden, except for one tiny blue flower that said, "Forget me not!"

Scientific classification. Forget-me-nots belong to the borage family, Boraginaceae. The water forget-me-not is *Myosotis scorpioides.*

See also **Flower** (picture: Flowers of Alpine tundras).

Forging is a process in which metal is shaped by being heated and then hammered or pressed. Almost any metal can be forged, but the most commonly forged ones include steel and aluminium, and alloys of nickel and titanium. *Forgings* (objects made by forging) range in size from small hand tools to huge engine shafts weighing hundreds of tons. They include such products as wrenches, crankshafts, axles, and aircraft landing gear supports.

Metals are composed of crystals. The hammering or pressing of metal bends the crystals and makes their structure less stable. But the heat used in forging enables new crystals to form in place of the deformed ones. This process is called *recrystallization.* In most cases, the new crystals are smaller and the metal is tougher than before. For this reason, forging is used in manufacturing many metal products that must withstand great stress.

Metal can be forged either by hand, using a hand-held hammer, or by machine. Hand forging, which is probably the oldest method of shaping metal, has been practised since prehistoric times. Today, however, nearly all forging is done by machine on an industrial scale.

Hand forging is used primarily for small forgings and in repair work. It is practised by blacksmiths, who forge horseshoes and other small iron objects. Blacksmiths first heat iron in a *forge* (open furnace) until it becomes red-hot. Then they remove the iron with tongs and, while the metal is still hot, hammer it into shape, holding it against an *anvil* (heavy iron or steel block). See **Blacksmith.**

Machine forging enables forgings to be mass-produced. Forging machines differ in size and can handle objects that are far too heavy to forge by hand. Large cranes must be used to turn some of the heaviest forgings on the anvils.

There are two kinds of forging machines, *forging hammers* and *forging presses.* Both use precision-made hollow tools called *dies* to help shape metal. The metal is forced into the die and takes the shape of the die's cavity.

Forging hammers shape metal by striking it repeatedly in rapid succession. The power to raise the hammer is provided by steam, hydraulic energy (transmitted by water or some other fluid), or electricity. In some forging hammers, the power also lowers the hammer. In other machines, called *drop hammers,* the hammer falls by its own weight. Forging hammers are used to shape most small forgings.

Forging presses squeeze metal into shape. Pressing is a much slower process than hammering, but only a press can provide the force necessary to make the most massive forgings. Pressing also causes less shock to the machine and the building that houses it than hammering does. Most forging presses are powered by hydraulic energy.

Dies that help shape forgings may be paired or single. Paired dies are used to make tools, engine parts, and other forgings that have complex shapes. The upper die is attached to the hammer or the moving part of the press, and the lower die to the anvil. Items produced by paired dies are called *closed die forgings* or, if a drop hammer is used, *drop forgings.*

See also **Die and diemaking; Steam hammer.**

Blacksmiths, *above,* forge horseshoes and other small iron objects by hand. Blacksmiths heat the iron to a red glow in a *forge* (open furnace) before they hammer it into shape.

A huge steel forging emerges from a forging press at a steel mill. Forging presses squeeze red-hot metal into a desired shape by forcing it into a die.

Formaldehyde is a colourless toxic gas with the formula CH_2O. It is probably most familiar as the active ingredient in the solution used to preserve insects and other biological specimens. This solution, called *formalin*, is a water solution containing 35 to 40 per cent formaldehyde by weight. Formaldehyde itself is the simplest member of the class of organic chemicals called *aldehydes*. It boils at -21° C.

Formaldehyde was discovered in 1867 by August Wilhelm von Hofmann, a German chemist. It is made commercially by the oxidation of methanol (methyl alcohol). Formaldehyde is used for disinfecting, for embalming, and for preserving grains and vegetables. It is also used in the manufacture of pharmaceuticals, urea resins, and dyes. The plastics industry prepares Bakelite from formaldehyde and phenol (see **Bakelite**).

Formaldehyde has a stifling odour and can irritate membranes of the eyes, nose, and throat. In addition, laboratory tests have shown that formaldehyde probably causes cancer.

See also **Aldehyde**; **Methanol**.

Formalin. See **Formaldehyde**.

Formby, George (1904-1961), a British comedian, began his career in music hall and later won fame through films and radio. With his ukulele, and in a broad Lancashire accent, he sang "When I'm Cleaning Windows," "Leaning on a Lamp-Post," and many other popular songs. He always appeared as an innocent and good-natured character in trouble. Formby was born in Wigan, Greater Manchester, England.

Formic acid is an important industrial chemical. Leather manufacturers use formic acid for tanning and for removing hair from animal skins. It is also used in the manufacture of dyes, rubber, and many other products.

Formic acid has the chemical formula CH_2O_2. In its pure form, the acid is a strong-smelling, colourless liquid. It is highly corrosive and can cause severe burns if it comes in contact with a person's skin.

Formic acid gets its name from *Formica rufa*, the scientific name for a species of red ants. The acid was originally obtained by the destruction and distillation of these ants. Today, formic acid is produced in a two-step process. First, carbon monoxide and sodium hydroxide are heated under pressure to form sodium formate. This salt is then treated with hydrogen chloride to liberate the formic acid.

Formosa. See **Taiwan**.

Formula. See **Algebra** (Writing formulas); **Chemistry**.

Formula One racing. See **Car racing** (Formula One racing).

Forrest is the family name of two brothers, born in Australia, who did much for Australian exploration and politics.

Sir John Forrest (1847-1918) led expeditions across Western Australia between 1869 and 1874. When the colony gained responsible government in 1890, he became its first premier. In 1901, he was elected to the first federal Parliament. In 1918, he became the first Australian-born peer when he was made first Baron Forrest of Bunbury.

Alexander Forrest (1849-1901) accompanied his brother on his expeditions, and in 1879, led his own expedition into the northern regions of Western Australia. In 1890, he became a member of the first state parliament.

Early lives. Both John and Alexander were born at Bunbury, in Western Australia. Their father, William Forrest, was a miller and farmer. Both brothers became surveyors.

Exploration. In March 1869, John Forrest was asked to lead and navigate for the botanist Ferdinand von Mueller and his party. Mueller was preparing an expedition from Perth to try to detemine what had happened to the German explorer Ludwig Leichhardt, who had disappeared with his group. Mueller's party traversed 3,200 kilometres of previously unknown country. They named a number of geographical features. But they found no trace of the missing men. During the following year, accompanied by Alexander, John Forrest crossed the southern portion of the continent from Perth to Adelaide, following approximately the same route taken by John Eyre in 1839. The Forrest party discovered the Eucla pastoral country, but suffered incredible hardships during the five-month journey.

Two years later, Alexander led a party from Kalgoorlie east and then south to Esperance. The rich pastoral country he discovered was later leased.

In 1874, Alexander joined John's expedition to explore the Murchison and Gascoyne districts and the unknown centre of the colony. Some people believed that a vast inland river system drained this area. The Forrests proved that this belief was wrong. They were also the first to make the crossing from the west coast to the Overland Telegraph, which ran from southern Australia to Darwin in the north. The brothers were accompanied by such skilled Aboriginal trackers as Tommy Windich.

On April 1, 1874, John left Geraldton with an expedition of 5 experienced men and 21 horses, bound for the

The Forrest brothers explored much of Western Australia between 1869 and 1879. Travelling together or separately, they made five journeys eastward from the coast during that period.

head of the Murchison River. In June, the expedition was attacked at Weld Springs by 30 or 40 Aborigines. They fired at their attackers, severely wounding one Aborigine and causing the rest to flee.

The expedition had to proceed from one water hole to the next, since the horses needed water every 12 hours. The party nearly died of thirst as they crossed the desert, but toward the end of the journey, they enjoyed some good fortune. Rain, which was rare in the area, fell ahead of the party and filled rock holes and claypans. On September 27, they sighted the Overland Telegraph Line. On Nov. 3, 1874, they reached Adelaide, where they were enthusiastically greeted.

Shortly after this expedition, John made a trip to England. There he published a book *Explorations in Australia*. In early 1876, he was invited to become a member of the Royal Geographical Society. One of the two gold medals presented yearly by the society for outstanding work in exploration was awarded to him.

In 1879, the two brothers headed a party to survey the recently settled country between the De Grey and Ashburton rivers in the northwest. In 1879, Alexander led a party to explore and map the unknown Kimberley district in the extreme northern region of the colony. There he discovered millions of hectares of pastoral country. Alexander published his *Journal of Expedition from De Grey to Port Darwin* in 1880.

Political careers. In 1883, John Forrest was appointed surveyor general. This appointment made him the first colonial-born individual to serve on the Executive Council.

In 1890, the colony received responsible government. John Forrest became Western Australia's first premier and treasurer. During the next decade, gold discoveries attracted new settlers, and the population quadrupled. Public revenue increased from 800,000 Australian dollars to nearly 6 million Australian dollars a year. Forrest set up public works schemes for railways, water supplies, and means of communication. The royal mint was established. The Agricultural Bank, founded in Forrest's time, greatly helped farmers, who could now borrow money to develop their land. Forrest's administration liberalized voting regulations, and earlier property qualifications for electors were removed. One of the greatest works carried out under Forrest was the construction of the Fremantle Harbour. All vessels could use this harbour, and they no longer had to sail to King George Sound. The confidence of the government in these schemes and the famed engineering venture under Charles Yelverton O'Connor of pumping water to the goldfields inspired investors abroad to lend money to the colony.

John Forrest also took an active part in discussions within federal councils and conventions. He did not feel that federation would be in Western Australia's best interests. Because the state had received its independence after the other colonies, he feared it would have difficulty maintaining equal status.

After federation in 1901, Forrest was elected to the new Parliament unopposed. He became successively postmaster general, minister for defence, and minister for home affairs. He served as treasurer in five federal cabinets. Forrest also played a significant part in the formation of the two-party political system in Australia. In 1918, he was the only member of the first federal Cabinet still in active politics. John Forrest was a big man, and had an overbearing and forceful manner.

Alexander Forrest, working as a land agent, helped develop the Kimberley area. It was proclaimed a new electorate in 1887, and he was returned as member. After the government divided the area, in 1890, he represented West Kimberley. He held that seat until his death. He also served as mayor of Perth from 1892 to 1895 and from 1897 to 1900.

See also **Australia, History of** (map).

Forster, E. M. (1879-1970) was an English novelist, essayist, and literary critic. His novels show his interest in personal relationships and in the social, psychological, and racial obstacles to such relationships. His fiction stresses the value of following generous impulses.

Forster's most highly praised novels are *Howards End* (1910) and *A Passage to India* (1924). *Howards End* is a social comedy with tragic overtones about several English middle-class characters. It reflects Forster's ideal of an "aristocracy of the sensitive, the considerate, and the plucky." *A Passage to India* describes the clash between English and traditional Indian cultures in India. Forster's other four novels are *Where Angels Fear to Tread* (1905), *The Longest Journey* (1907), *A Room with a View* (1908), and *Maurice* (completed in 1914, published in 1971, after the author's death).


E. M. Forster

For the last 46 years of his life, Forster produced only nonfiction. But he wrote his essays, biographies, and literary criticism in a masterly style noted for the same grace, polish, and elegant wit that characterized his novels. Edward Morgan Forster was born in London.

See also **Bloomsbury Group**.

Forster, William Edward (1818-1886), was a Liberal politician who did much to make education available to all in the United Kingdom. As a member of the Cabinet, he was responsible for the Elementary Education Act of 1870. This act established the principle that public authorities could provide schools. It increased grants to existing primary schools, and empowered local school boards to provide other primary schools.

Forster was born at Bradpole, in Dorset, England. He became a member of Parliament in 1861.

Forsythia is one of several species of shrubs that belong to the olive family. It grows to about 3 metres high and has spreading, arched branches. One to six bell-shaped, yellow flowers grow in clusters. Forsythias produce many blossoms, which open in early spring before the leaves appear. The leaves can grow to between 8 and 13 centimetres long and are egg-shaped. They usually have jagged edges. Forsythias grow well in any garden soil and can withstand cold temperatures. The old wood needs pruning well back after the plant has flowered. The forsythia is named after the British botanist William Forsyth.

The forsythia is a hardy, spreading shrub. It blooms in early spring and has tiny bell-shaped yellow flowers.

Fort-de-France lies on the west coast of the island of Martinique. An attractive city, it is a financial and shipping centre

Scientific classification. Forsythias belong to the olive family, Oleaceae, genus *Forsythia*.

See also **Flower** (picture: Garden perennials).

Fort-de-France (pop. 99,844), is the capital of Martinique, an island in the West Indies that is an overseas department of France. It lies on the west coast of the island. For location, see **West Indies** (map).

Fort-de-France has palm-lined streets, brightly coloured buildings, and a waterfront park. It is a shipping centre for sugar, rum, fruit, and other products. It is also Martinique's financial centre. The city attracts many tourists. A French naval base is located there.

Fort-de-France was founded in 1675. It was called Fort Royal until the late 1700's, when it received its present name. The city has been the capital of Martinique since 1692. The city was partially destroyed by an earthquake in 1839 and by a fire in 1890.

See also **Martinique.**

Fort Dearborn was built near the mouth of the Chicago River, close to the site of the present Michigan Avenue Bridge in Chicago. Soldiers under the command of Captain John Whistler built the fort in 1803. It was named after General Henry Dearborn. The double stockade had blockhouses on two corners, enclosed log barracks, stables, and an Indian agency.

A garrison of soldiers at the fort protected the few Americans on the frontier from Indian attack. Soon after the War of 1812 began, the troops and settlers were ordered to move to Fort Wayne, Indiana, where they would be safer.

A band of 500 Potawatomi and allied Indians attacked the Americans near the fort. They killed more than half of the Americans, captured the rest, and burned the fort the next day.

Fort Dearborn was rebuilt about 1816, and torn down in 1836.

A replica of Fort Dearborn, Chicago, was built in 1933 for Chicago's Century of Progress Exposition, and later dismantled. It contained articles used by settlers in the early 1800's.

Fort Denison was built on an island in Sydney Harbour, Australia, between 1841 and 1857. In the early years of settlement, before a prison was built on shore, the authorities sometimes marooned criminals on the island for long periods of time with only small amounts of rations. The fort's popular name, *Pinchgut*, derived from this practice. It now houses a seismograph, a lighthouse, and a tide gauge.

Fort Knox, Kentucky, U.S.A., houses the United States Army Armor Center. This command includes the armour school, armour board, bullion depository, and armour training centre. The post covers 44,500 hectares, and lies about 55 kilometres south of Louisville. The government took over part of the present post for army manoeuvres in 1918. Camp Knox was established in 1918, and named after Major General Henry Knox, the first secretary of war. Its name became Fort Knox in 1933. The post has been called "the Home of Armor," because the Army created its first armoured force there in 1940.

The U.S. Treasury Department completed its gold depository there in 1936. The depository contains more than 6 billion U.S. dollars worth of gold. During World War II, the Constitution, Declaration of Independence,

The gold depository at Fort Knox, Kentucky, U.S.A., contains more than 6 billion U.S. dollars worth of the gold owned by the United States government.

Gutenberg Bible, Lincoln's Gettysburg Address, and Magna Carta were placed in the depository at Fort Knox for safekeeping.

Fort-Lamy. See N'djamena.

Fort Sumter was the first Union fort captured by the Confederates during the American Civil War (1861-1865).

In April 1861, Pierre Beauregard, a Confederate general, demanded the surrender of the fort. Major Robert Anderson (1805-1871), who directed the defences of Charleston harbour in South Carolina, refused. The vigorous bombardment that followed began the American Civil War. On April 14, Union troops evacuated the fort. The Confederates permitted Anderson and his command to leave with their weapons and their flag. The Confederates held Fort Sumter until February 1865.

See also **American Civil War** (Opening battles; picture: Fort Sumter).

Fort Ticonderoga, on Lake Champlain in New York, U.S.A., was an important stronghold during the American Revolution. It commanded the invasion route by water from Canada. When hostilities began, a group of Americans organized an expedition to seize the fort. The group included Ethan Allen, a Vermont colonial leader. On May 10, 1775, Allen and Benedict Arnold led the *Green Mountain Boys* (Vermont soldiers) in a surprise attack and captured the fort without loss of life. The British recaptured the fort in 1777, but later abandoned it in 1780 when they gave up hope of using the invasion route.

In 1908, the fort was rebuilt, and a museum was opened there. The museum contains articles used by soldiers of the revolution.

Fort Worth, Texas, U.S.A. (pop. 447,619; met. area pop. 1,332,053), is a major industrial city and one of America's chief aircraft producers. It is a leader among the Southwestern cities as a market for grain and oil. Fort Worth lies about 48 kilometres west of Dallas in north-central Texas. It's largest industries make aeroplanes, helicopters, and electronic equipment. Other products include food products, oil-well equipment, and shipping containers. Fort Worth is also one of the Southwest's leading grain-milling and storage centres.

Fortaleza (pop. 648,815; met. area pop. 1,581,588), is a city on the northeast coast of Brazil. For location, see **Brazil** (political map). Fortaleza is the capital of the state of Ceará. The Metropolitan Cathedral, a large Gothic church, is a major landmark of the city. Fortaleza's economy depends largely on the activities of the state and city governments and on the processing and export of such products as cotton and carnauba wax.

Fortaleza was first settled in the early 1600's, when the Portuguese built a fort there. It received the status of a town in 1711. In 1799, it became the capital of Ceara. Fortaleza has experienced rapid growth since the mid-1900's. The city now has more than five times as many people as it had in 1950.

Forth is one of the main rivers of Scotland. It rises in the hills to the east of Loch Lomond and flows generally eastwards to the Firth of Forth and the North Sea. Most of the upper reaches of the River Forth flow through Central Region. The river is nearly 190 kilometres long, including the Firth of Forth. Important towns and cities on the Forth include Stirling, Alloa, and Edinburgh. Road bridges span the river at Queensferry and at Kincardine. A railway bridge also spans the Forth at Queensferry. The lower reaches of the Forth are a leading port area, particularly for North Sea oil.

See also **Central Region; Firth of Forth.**

FORTRAN. See Computer (Using programming languages).

Fortuna was the goddess of luck in Roman mythology. Fortuna was associated solely with good fortune in early Roman religion. However, after she became identified with Tyche, the Greek goddess of chance, she was also considered a giver of bad luck. Fortuna often is shown with a wheel that she turned to bring success or failure. She also appears with a rudder, symbolizing her power to steer people's lives. The word *fortune* comes from her name.

Fortunetelling is the practice of predicting future events by methods generally considered illogical and unscientific. Persons who claim to foretell the future are called *fortunetellers*.

Some fortunetellers say they possess a form of *clairvoyance* that makes them aware of events before they occur. Clairvoyance is the knowledge of events, objects, or people without using any known senses. Scientists do not know whether clairvoyance actually exists. Most fortunetellers do not claim to have clairvoyant powers. Instead, they use special systems of prediction. Some of these systems are complicated, and fortunetellers often say they are scientific. But most scientists consider such systems to be *pseudosciences* (false sciences).

Fortunetelling has been especially popular during certain periods of history. For example, the ancient Greeks and Romans believed the gods spoke to them through prophets called *oracles*. Many people went to oracles for advice about the future. In later times, the Christian church discouraged fortunetelling. However, an ancient type of fortunetelling called *astrology* became extremely popular in Europe during the Renaissance, the period from about 1300 to about 1600. Some forms of fortunetelling remain popular today, especially in primitive societies and developing countries. Most people in the Western world regard fortunetelling as a form of amusement, but many believe in it sincerely.

Methods of fortunetelling. Throughout history, hundreds of different fortunetelling methods have been used. One of the most famous methods involves gazing into a crystal ball. Many methods of fortunetelling seem to depend entirely on chance. For example, fortunetellers have made predictions based on the order in which a cock ate grains of wheat placed on letters drawn on the ground. Predictions also have been based on the shape taken by oil poured on water, or on segments of writing chosen from a book at random.

However, fortunetellers claim that mysterious causes and relationships, not chance, make their predictions possible. For example, astrology is based on the belief that the sun, moon, planets, and stars control the lives of human beings. Therefore, the positions and movements of these celestial bodies supposedly can be used to predict the future.

Other fortunetelling systems include *numerology* and *palmistry*. In numerology, a fortuneteller makes predictions through numbers based on a person's name and birth date. In palmistry, a fortuneteller tries to foresee an individual's future by studying the lines, markings, shape, and the size of the person's hand.

Some fortunetellers only pretend to rely on special systems. For example, a fortuneteller may investigate a client's background and then impress the client by relating many things from this background information. A fortuneteller also may rely on a broad knowledge of human nature. The fortuneteller knows what most people want to hear and so makes statements about the future that could apply to almost anyone. The fortuneteller then observes the client's reactions to these statements and develops a more detailed prediction on the basis of these reactions.

Dangers of fortunetelling. Most fortunetelling is based on the idea that mysterious forces control human life. Therefore, a belief in fortunetelling may rob people of trust in their own ability to control the future. Also, some individuals have lost large sums of money to dishonest fortunetellers.

Some people argue that honest fortunetellers may give harmless—and even sensible—advice to troubled people who cannot afford psychiatric help. However there have been cases of businesses and marriages being wrecked because a person has acted on bad advice given by a fortuneteller.

Related articles in *World Book* include:

Astrology	Magic	Omen
Augur	Necromancy	Oracle
Clairvoyance	Nostradamus	Palmistry
Divination	Numerology	Superstition
Graphology	Occultism	

Forty-Niner was a gold-seeker who rushed to California, U.S.A., after gold was discovered there in 1848. The first Forty-Niners reached San Francisco on the steamer *California* on Feb. 28, 1849. Ships from all parts of the world carried other gold-seekers there. But the greatest number arrived in covered wagons by way of the Oregon Trail and the California Trail. Gold seekers increased California's population from about 15,000 early in 1848 to over 100,000 by the end of 1849. The Forty-Niners were the first of still heavier migrations to California during the following years. See also **Gold rush** (picture).

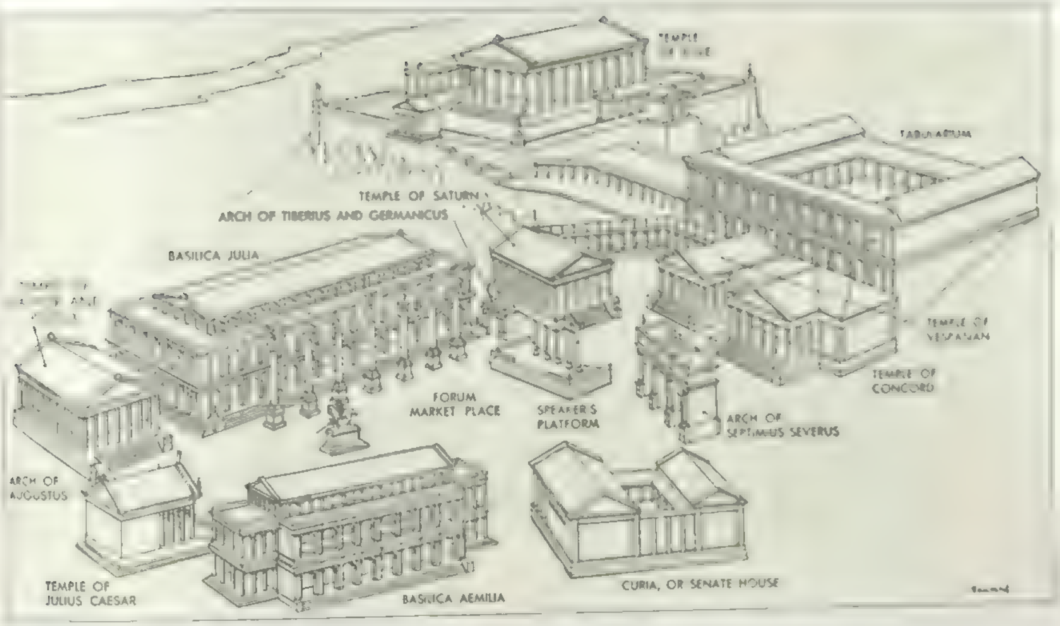
Forum, Roman, was the section of ancient Rome that served as the centre of government. It was the administrative, legislative, and legal centre of the Republic and of the Roman Empire. Many important and beautiful buildings and monuments stood in the Forum. These included the *Curia* (Senate House), the temples of Concord and Saturn, the Basilica Julia and Basilica Aemilia, the Arch of Septimius Severus, and the *Tabularium* (Hall of Records).

Events in the Forum often affected the rest of the known world. Marcus Tullius Cicero's stirring speeches on the floor of the Curia in the 60's B.C. saved the Republic from a rebellion led by Catiline. There, too, in 27 B.C. the senate gave Augustus the powers that made him the first emperor of Rome. Romans went to the Forum to hear famous orators speak and to see the valuables seized after distant battles.

In Rome's earliest days, the Forum area was a swamp used as a cemetery by the people of surrounding villages. The Etruscans turned these villages into the city of Rome and drained the marshes, probably during the 500's B.C. Residents built shops and temples around the edges of the Forum area. The Forum became the civic and legal centre of Rome by the mid-100's B.C., and the merchants moved their shops to other parts of the city.

The barbarians who invaded Rome in the A.D. 400's did not destroy the Forum. But the Forum's buildings gradually crumbled after the fall of Rome, and people came to call the Forum *Cow Plain* because it had become so desolate. Excavations have since uncovered many of the ancient columns and arches. Rome had other forums, some with architecture as outstanding as that of the Roman Forum. Several emperors named forums in their own honour. But only the first forum was called *Forum Romanum* (Roman Forum).

See also **Rome** (Forums; picture: Roman Forum); **Rome, Ancient** (picture).



The early Roman Forum had this arrangement during the period of its greatest magnificence.

Foscolo, Ugo (1778-1827), was an Italian author. His *Le ultime lettere di Jacopo Ortis* (1802, revised in 1817), is sometimes considered the first modern Italian novel. It is the tragic story of a young student's love for Teresa, a woman whose hand has been promised to another man, Odardo. The story is told in the form of letters, and shows the influence of Johann Wolfgang von Goethe's *The Sorrows of Young Werther*. Many of Foscolo's odes and sonnets tell in a lyrical yet classical style about his personal sufferings and disappointments. His best-known poem, *Dei sepolcri (The Sepulchres)* (1806-1807), is an ode that stresses the importance of graves as living reminders of one's ancestors.

Foscolo was born on the island of Zákinthos in the Ionian Sea. His early poetry is filled with his desire to see Italy unified. In 1815, Foscolo left Italy for England, where he taught Italian and wrote essays for magazines and newspapers.

Fossey, Dian (1932-1985), was an American zoologist who studied the mountain gorillas of the Virunga Mountains in east-central Africa. She founded the Karisoke Research Centre in Rwanda and lived there in near-isolation for almost 18 years. Fossey's research on wild mountain gorillas led to efforts to protect this rare and endangered species. She was mysteriously murdered at her camp in Rwanda in December 1985.

Fossey was born in San Francisco, California, U.S.A. She received a bachelor's degree in occupational therapy from San Jose State College (now San Jose State University) in 1954. In 1963, inspired by a book about mountain gorillas by American zoologist George Schaller, Fossey borrowed money and travelled to Africa to see the animals. There, Fossey visited the camp of British anthropologist Louis Leakey. In 1966, Leakey picked Fossey to begin a long-term field study of the animals. Fossey received a doctorate for her gorilla research from Cambridge University, England, in 1974.

To gain acceptance by the mountain gorillas, Fossey imitated their habits and sounds. She studied them daily and came to know each animal individually. After several of her favourite mountain gorillas were killed, Fossey focused on protecting the animals from poachers and from the destruction of their mountain habitat. Some United States officials believe Fossey may have been murdered by poachers angered by her strong attempts to protect the animals. Fossey described her research in the book *Gorillas in the Mist* (1983). A film about her with the same title was released in 1988.

Dian Fossey studied and photographed mountain gorillas in Africa. She won their trust by imitating their sounds and habits.

Fossils, such as these dinosaur skeletons, help museum visitors visualize ancient species. Scientists study fossils to learn about the development and ways of life of prehistoric organisms

Fossil

Fossil is the mark or remains of a plant or animal that lived thousands or millions of years ago. Some fossils are leaves, shells, or skeletons that were preserved after a plant or animal died. Others are tracks or trails left by moving animals.

Most fossils are found in *sedimentary rocks.* These fossils formed from plant or animal remains that were quickly buried in *sediments*—the mud or sand that collects at the bottom of rivers, lakes, swamps, and seas. After thousands of years, the weight of the upper layers of sediment pressing down on the lower layers turned them into rock (see **Sedimentary rock**). A few fossils are whole plants or animals that have been preserved in ice, tar, or hardened sap from trees.

The oldest fossils are microscopic traces of bacteria that scientists believe lived about $3\frac{1}{2}$ billion years ago. Such fossils have been found in a rock called *chert* (a variety of quartz) in South Africa. Similar fossils of ancient, single-celled bacteria have also been found in Australia. The oldest animal fossils are the remains of *invertebrates* (animals without a backbone). These fossils are estimated to be about 700 million years old. The oldest fossils of *vertebrates* (animals with a backbone) are fossil fish about 500 million years old.

Fossils are more common and easier to find than many people realize. Fossils are plentiful in most parts of the world. This is because sedimentary rocks are common, covering about 75 per cent of the earth's land surface. Even so, scientists believe that only a small proportion of the countless plants and animals that have lived on earth have been preserved as fossils. Many species are thought to have lived and died without leaving any trace whatsoever in the fossil record. But more fossil species are being discovered all the time.

Although the fossil record is incomplete, many important groups of animals and plants have left fossil remains. These fossils help scientists discover what forms of life existed at various periods in the past and how these prehistoric species lived. Fossils also indicate how life on earth has gradually changed over time. This article explains how fossils provide information on ancient life. For a description of animals of the past, see **Prehistoric animal;** for a description of early human beings, see **Prehistoric people.**

How fossils reveal the past

In the distant past, when most fossils formed, the world was different from today. Plants and animals that have long since vanished inhabited the waters and land. A region now covered with high mountains may have been the floor of an ancient sea. Where a lush tropical forest thrived millions of years ago, there may now be a cool, dry plain. Even the continents have drifted far

from the positions they occupied hundreds of millions of years ago. No human beings were present then to record these changes. But *palaeontologists* (scientists who study prehistoric life) have pieced together much of the story of the earth's past by examining its fossil record.

Understanding ancient plants and animals. By studying fossils, palaeontologists can learn a great deal about the appearance and ways of life of prehistoric organisms. One way palaeontologists learn about a fossil animal or plant is by comparing it with living species. In many cases the comparisons show that the fossil species has close living relatives. Similarities and differences between the fossil species and its living relatives can provide important information. For example, fossils show that *Homo erectus*—a species that lived from about 1,800,000 to 300,000 years ago—was an ancient ancestor of modern human beings. Its fossilized pelvis, leg, and foot bones are similar in structure to modern human bones. Palaeontologists know that the bones of modern humans are designed for walking upright. From this evidence, they have determined that *Homo erectus* also walked upright (see **Homo erectus**).

Fossil plants and animals that do not have close living relatives are more difficult to understand. One way to learn how they lived is to compare their fossils to unrelated living species that have similarly shaped structures. For example, fossils show that about 210 million to 65 million years ago there lived a group of reptiles with one long, slender finger extending from each front limb. This bone structure does not resemble that of any living reptile. It appears, however, similar to the wings of modern birds. Since modern birds use their wings for flying, palaeontologists conclude that these ancient creatures also flew. Palaeontologists call them *pterosaurs,* which means *winged lizards.*

The conditions under which fossil creatures died and were buried can also reveal how they lived. Palaeontologists have found fossil nests of partially grown baby dinosaurs. These fossils indicate that certain species of dinosaurs fed and cared for their young in nests, much as today's birds do.

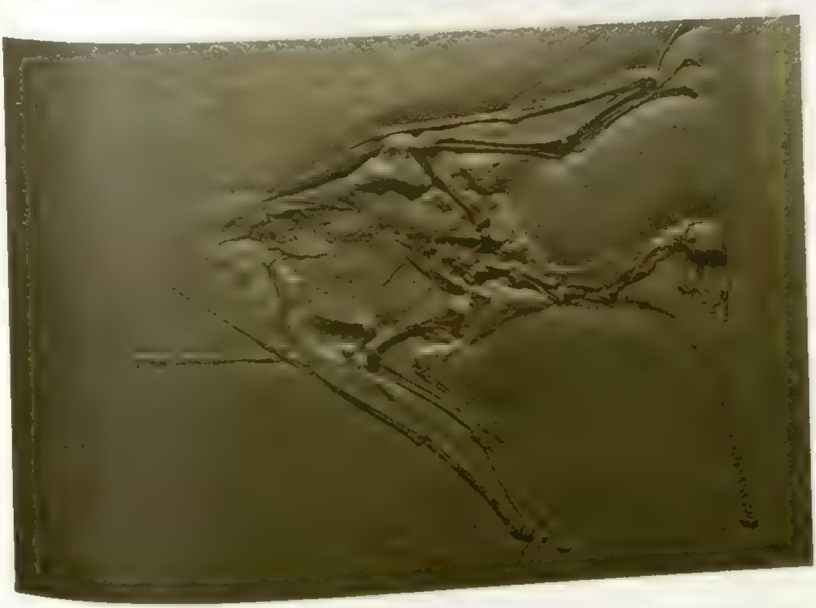
Fossils of tracks, trails, or burrows—called *trace fossils*—provide information on the behaviour of prehistoric animals. Groups of dinosaur tracks, for example, suggest that some species of dinosaurs travelled in herds. Other trace fossils show that primitive worms lived in simple tubes dug in the sea floor.

Tracing the development of life. The fossil record provides important evidence of the history of life. Fossils indicate that over hundreds of millions of years life on earth has *evolved* (developed gradually) from simple, one-celled bacteria and algae into a tremendous variety of complex organisms. Fossils also indicate that certain species changed dramatically, giving rise to entirely new forms of life.

The location of fossils in the *strata* (layers) of sedimentary rock can show how living things increased in complexity over time. As sediment was deposited, new layers settled on top of older ones. When the sediment turned to stone, these layers were preserved in the order in which they were laid down. In undisturbed strata, fossils in the lower—and thus older—layers are more primitive than those in the younger strata found nearer the surface.

The fossils preserved in the strata of the Grand Canyon in Arizona, U.S.A., provide a good example of the increasing complexity of living things. Strata near the bottom are about 1 billion years old and contain only primitive fossil algae. Strata dating from 600 million to 500 million years ago contain fossils of invertebrates, including extinct sea animals called *trilobites.* Remains of fish first appear in strata about 400 million years old. Some of the strata which formed between 330 million and 260 million years ago contain tracks of such early land animals as amphibians and small reptiles.

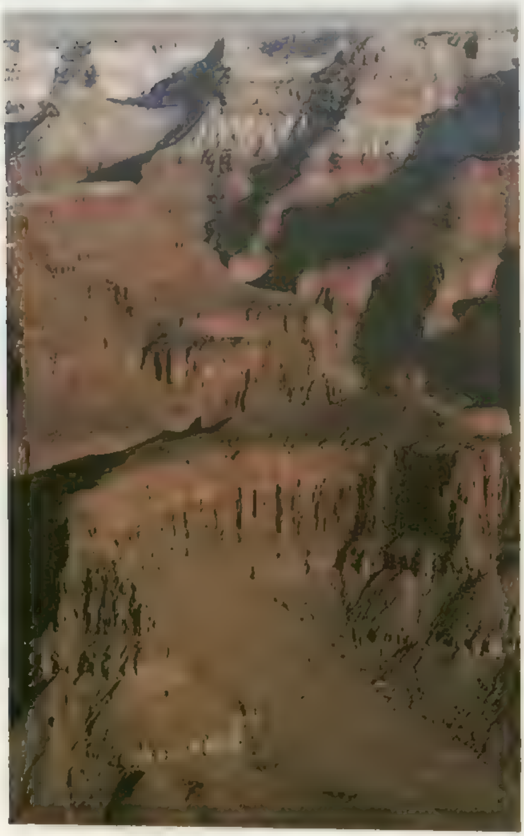
Certain fossils indicate that particular groups of plants or animals evolved from others. These *transition fossils* combine characteristics of two major groups. For example, fossil skeletons of *Ichthyostega,* a creature that lived

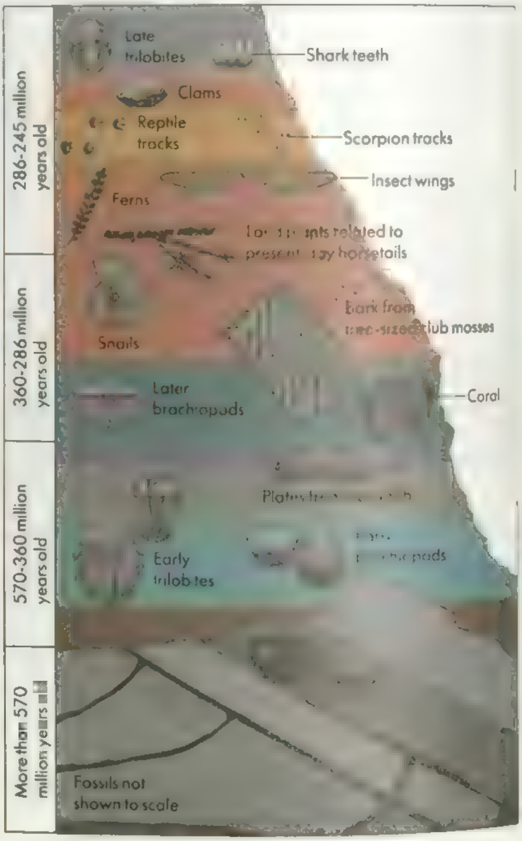


A fossil *Pterodactylus,* a type of pterosaur, provides information on the animal's behaviour. The long, slender finger bones, which are similar to birds' wings, indicate that *Pterodactylus* flew. Its tapered snout and sharp teeth suggest that it fed on worms and other burrowing creatures, plucking them out of the earth as some modern birds do.

Tracing the history of life

In the Grand Canyon, in Arizona, U.S.A., many *strata* (layers) of sedimentary rock are exposed, *left.* Fossils in the strata show how living things increased in complexity over time. The oldest strata in the diagram on the right contain only simple fossil algae. Primitive sea animals — trilobites and brachiopods — appear in the next oldest strata. Younger strata, by contrast, contain fossils of more complex organisms, including traces of plants, fish, and reptiles.





about 360 million years ago, provide evidence that amphibians evolved from fish. Palaeontologists classify *Ichthyostega* as one of the first amphibians because it had legs and lungs, enabling it to live on land. *Ichthyostega*'s leg bones, however, were similar to the fin bones of fish. It also had fishlike teeth and a broad, finned tail for swimming. Fossils indicate that later amphibians lost these fishlike traits and became better adapted to life on land.

Fossils also show how groups of plants and animals became more diverse after they originated. Fossil leaves and pollen grains of the first flowering plants date from the early Cretaceous Period, sometime after 138 million years ago. These fossils record only a small number of species. Fossils from the mid-Cretaceous, about 90 million years ago, include a wide variety of flowering plants from many different environments.

Recording changes in the earth. Palaeontologists use fossils to determine how the earth's climate and landscape have changed over millions of years. For instance, they have found fossils of tropical palm trees in areas that have a *temperate* (cool) climate today. Also, layers of coal, a fossil fuel that consists of the remains of plants that died millions of years ago, have been found in Antarctica, where it is now much too cold for such plants to grow. Such evidence indicates that the climate of these areas has changed. Palaeontologists have also found fossils of seashells in rocks that are far inland today. Such fossils reveal that seawater once spread over these areas.

Fossils also provide evidence supporting the theory of *continental drift*—the idea that the positions of continents have changed over hundreds of millions of years.

Fossils reveal ancient environments. A fossil palm, *left,* suggests that temperate regions once had a tropical climate. Fossil oysters, *right,* indicate that a sea once covered inland areas.

Palaeontologists have found similar kinds of fossil dinosaurs on all of the modern continents. It is unlikely that similar species could have evolved on separate continents. As a result, most earth scientists believe that when the dinosaurs first appeared—about 240 million years ago—nearly all the earth's land mass was united as a single supercontinent. In contrast, fossils of mammals show complex differences from continent to continent. This indicates that after about 200 million years ago, when mammals were beginning to develop and spread, the supercontinent was breaking apart. The continents were drifting slowly to the positions they occupy today.

The theory helps to explain, for example, the evolution in Australia of marsupials, which are unlike any other animals in the rest of the world. See **Continental drift.**

How fossils form

The great majority of plants and animals die and decay without leaving any trace in the fossil record. Bacteria and other microorganisms break down such soft tissues as leaves or flesh. As a result, these tissues rarely leave fossil records. Even most hard parts, such as bones, teeth, shells, and wood, are eventually worn away by moving water or dissolved by chemicals. But when plant or animal remains have been buried in sediment, they may become fossilized. These remains are occasionally preserved without much change. Most, however, are altered after burial. Many disappear completely, but still leave a fossil record in the sediment.

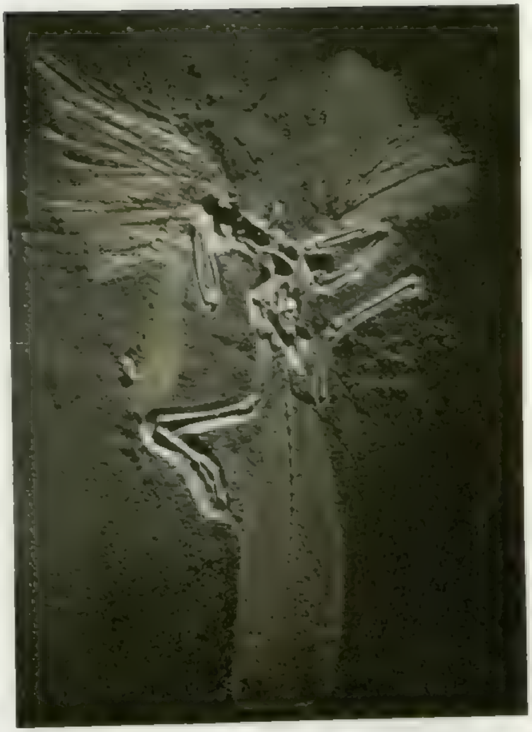
Fossils may be preserved in several ways. The main processes of fossilization are (1) the formation of impressions, moulds, and casts; (2) carbonization; and (3) the action of minerals.

Formation of impressions, moulds, and casts. Some fossils consist of the preserved form or outline of animal or plant remains. Impressions, also called *prints* or *imprints,* are shallow fossil depressions in rock. They form when thin plant or animal parts are buried in sediment and then decay. After the sediment has turned to stone, only the outline of the plant or animal is preserved. Many impressions consist of small grooves left by the bones of fish or the thick-walled veins found inside leaves. Sometimes even delicate soft parts, such as feathers or leaves, are preserved as impressions.

Moulds form after hard parts have been buried in mud, clay, or other material that turns to stone. Later, water dissolves the buried hard part, leaving a mould—a hollow space in the shape of the original hard part—inside the rock. A cast forms when water containing dissolved minerals and other fine particles later drains through a mould. The water deposits these substances, which eventually fill the mould, forming a copy of the original hard part. Many seashells are preserved as moulds or casts.

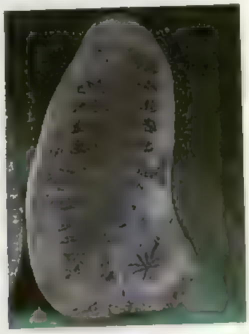
Carbonization results when decaying tissues leave behind traces of carbon. Living tissues are made up of compounds of carbon and other chemical elements. As decaying tissues are broken down into their chemical parts, most of the chemicals disappear. In carbonization, a thin, black film of carbon remains in the shape of the organism. Plants, fish, and soft-bodied creatures have been preserved in precise detail by carbonization.

The action of minerals. Many plants and animals became fossilized after water that contained minerals soaked into the pores of the original hard parts. This action is called *petrifaction.* In many such fossils, some or all of the original material remains, but it has been strengthened and preserved by the minerals. This process is called *permineralization.* Fossilized wood, ranging in size from small branches to huge tree trunks, has been found in several parts of the world. Some places have so much fossilized wood that the areas are called *petrified forests.* For example, northern Arizona, in the United States, contains the Petrified Forest National Park.



An impression of an archaeopteryx began to form when the bird was buried in soft silt. The silt turned to limestone, preserving the delicate outlines of the bird's wing and tail feathers.

A mould preserved the three-dimensional form of a trilobite after its body decayed.



A carbonized fossil of a fern consists of traces of carbon in the shape of the leaf.

Petrified wood formed after dissolved minerals were deposited in the pores of dead tree trunks. The structure of the wood including bark and growth rings, is visible in these specimens

The park claims to have the world's biggest and most colourful concentration of fossilized wood. See **Petrified forest.**

In other cases, the minerals in the water totally replaced the original plant or animal part. This process, called *replacement,* involves two events that happen at the same time: The water dissolves the compounds that make up the original material, while the minerals are deposited in their place. Replacement can duplicate even microscopic details of the original hard part.

A baby woolly mammoth was unearthed from the frozen ground in Alaska, U.S.A. Scientists can learn a great deal from such frozen fossils because much of their tissue is preserved intact.

Other processes. Occasionally, animal and plant structures are fossilized with little or no change. In *mummification,* an animal's skin and other tissues are preserved by drying or by the action of chemicals. Mummification may occur when a dead animal is buried in a dry place, such as a desert, or in asphalt or some other oily substance.

Some processes fossilize whole animals. Insects sometimes are preserved whole in *amber,* the hardened sap of ancient pines or other trees. Such insects were trapped in the sticky sap and then sealed when it turned to amber. In Alaska, in the United States, and in Siberia, a region in northern Asia, woolly mammoths thousands of years old have been found frozen in the ground. Their hair, skin, flesh, and internal organs have been preserved as they were when the mammoths died.

Studying fossils

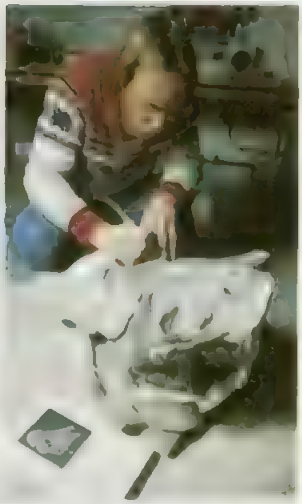
Discovering fossils. Fossils can be found wherever sedimentary rocks are exposed. In moist regions, these rocks are usually buried under a layer of soil and plant life, but they become exposed by water erosion in river valleys. Sedimentary layers also become uncovered during road construction and other building projects. In deserts and other arid regions, erosion exposes sedimentary rocks over broad areas. And oil-well drilling often brings up fossil-bearing sedimentary rocks from deep within the earth. The fossils in cores extracted from the earth by drilling often help oil prospectors to locate reserves of oil and natural gas.

Palaeontologists search in specific areas for particular types of fossils. In North America, for example, most fossil mammals are found west of the Mississippi River. Palaeontologists hunt for fossil ancestors of human beings in eastern and southern Africa. Canada and Australia have deposits of well-preserved ancient marine invertebrates.

Collecting fossils. Different fossils require different collecting techniques. Fossils of shells, teeth, and bones preserved in soft sand or mud are easiest to collect. Palaeontologists can dig out these fossils with a trowel or shovel or remove them by hand. Fossils preserved in hard rock are most easily found and collected when they have become exposed by natural *weathering.* Weathering refers to the chemical and physical processes that break down rock at the surface of the earth. Fossils that are more resistant to weathering than the surrounding rocks stand out on exposed rocky surfaces. Most such fossils can be collected by breaking loose the rock with a chisel, hammer, or pick. Palaeontologists collect fossils that are hidden in solid rock by breaking the rock with a sledge hammer or a hammer and chisel. Rocks containing fossils often break along the surfaces of the fossils.

Fragile fossils must be protected before they are broken out of rock. Palaeontologists wrap the exposed parts of such fossils in layers of cloth soaked with wet plaster. After the plaster hardens, the fossils can be safely chipped from the rock and transported to a laboratory, where the plaster is removed.

In the laboratory, palaeontologists use electric grinding tools, fine picks, and even needles to remove any remaining rock. Fossils enclosed in limestone may be



Removing fossils from rock requires patience and the proper tools. The fossil collectors in the photo above employ hammers and chisels to chip huge dinosaur bones from an exposed rock wall. In the laboratory, *right*, a technician uses a small, handheld jackhammer called an *air scribe* to remove rock from fragile fossil fragments.

soaked in a weak acid solution, which dissolves the limestone but not the fossil. Palaeontologists may decide to leave a fossil attractively exposed but still partly hidden in the rock.

Working with fragments. Many fossils are collected in fragments, which must be assembled like pieces of a jigsaw puzzle. In general, the first time a fossil species is reconstructed in this manner, the fragments must represent the complete specimen. Later reconstructions can be made from incomplete fragments by comparing them with the complete fossil and replacing the missing parts with artificial materials.

Vertebrate fossils can be reconstructed as *free mounts,* in which the skeleton seems to stand by itself. Palaeontologists first make a small model of the finished skeleton. They then construct a framework of steel, plastic, or other strong material to support the skeleton. Finally, they fasten the bones to the outside of the framework to hide it.

Classifying fossils. Like living plants and animals, fossil species are classified according to how closely related they are to one another. In general, scientists determine how closely related various species are by comparing their many biological features (see **Classification, Scientific**). For fossil groups, these features are primarily the shapes of hard parts, such as shells, teeth, and skeletons, because these are the features that are preserved. For example, palaeontologists may look at skull shape and tooth size when determining the different species of sabre-toothed tiger.

Dating fossils. Through many years of research, palaeontologists have come to understand the order in which most kinds of fossils occur in the geological record. When a fossil species is first discovered, it is usually found along with other species. If palaeontologists know the position of the other species in the history of life, they can determine the position of the new species. This type of dating indicates only whether one fossil is older or younger than another fossil. It does not provide a fossil's age in years.

Palaeontologists determine how old a fossil is by measuring the *radioactive isotopes* in the rocks that contain the fossil. Radioactive isotopes are forms of chemical elements that break down, or *decay,* to form other materials. Scientists know the rates of decay of various radioactive isotopes. By comparing the amount of a radioactive isotope in a rock to the amount of the material produced by its decay, scientists can calculate how long the decay has been taking place. This length of time represents the age of the rock and the fossils it contains.

Related articles in ***World Book*** include

Andrews, Roy Chapman
Ant (picture: Fossils of ants)
Anthropology (picture)
Coal (picture: Fossil ferns)
Cuvier, Baron
Dinosaur
Earth
Evolution
Geology
Insect (picture: Fossil imprint of a dragonfly)
Palaeontology
Plant (Early plants)
Rock (Organic sediments)
Teilhard de Chardin, Pierre
Tree (Fossil trees; picture)

Outline

I. How fossils reveal the past
- A. Understanding ancient plants and animals
- B. Tracing the development of life
- C. Recording changes in the earth

II. How fossils form
- A. Formation of impressions, moulds, and casts
- B. Carbonization
- C. The action of minerals
- D. Other processes

III. Studying fossils
- A. Discovering fossils
- B. Collecting fossils
- C. Working with fragments
- D. Classifying fossils
- E. Dating fossils

Questions

How are fossils formed by permineralization?
How do palaeontologists remove fossils from rocks?
What are the oldest fossils?
How do fossils support the theory of plate tectonics?
What are trace fossils?
How do palaeontologists date fossils?
Why do most fossils consist of preserved hard parts?
What is a free mount?
What do fossils reveal about the evolution of living things?
What features do palaeontologists use in classifying fossil species?

Fossil fuel. See Energy supply; Fuel.

Foster, Stephen Collins (1826-1864), was one of America's best-loved songwriters. He composed sentimental songs that were called "plantation melodies." These songs are deeply moving in their sincerity and their simplicity. Foster's most popular works include "Old Folks at Home" (also known as "Swanee River,"); "My Old Kentucky Home, Good Night," and "Massa's in de Cold, Cold Ground." He also wrote "Oh! Susanna," "Camptown Races," "Beautiful Dreamer," and "Jeanie with the Light Brown Hair." He composed more than 200 songs, writing both the words and the music for most of them.

Foster was born on July 4, 1826, near Lawrenceville (now part of Pittsburgh), Pennsylvania, U.S.A. He had little musical training, but he had a great gift for melody. At the age of 6, he taught himself to play the clarinet, and he could pick up any tune by ear. He composed "The Tioga Waltz" for piano at 14. Two years later his first song, "Open Thy Lattice, Love," was published.

He wrote his first minstrel melodies, which he called "Ethiopian songs," in 1845. These were "Lou'siana Belle" and "Old Uncle Ned." Blackface minstrel shows, in which white entertainers blackened their faces, were becoming popular in the United States (see **Minstrel show**). Foster decided to write songs for the minstrels and to improve the quality of their music.

Stephen Foster

He went to Cincinnati, Ohio, U.S.A., in 1846 to work as a bookkeeper for his brother. He wrote "Oh! Susanna" in 1846. Soon it became the favourite song of the "Forty-Niners" in the California gold rush. He married Jane McDowell in 1850, and settled in Pittsburgh to work as a composer. He arranged with the minstrel leader, E. P. Christy, to have his new songs performed on the minstrel stage. Foster was a poor businessman, and he sold many of his most famous songs for very little money. He lived in New York City from 1860 until his death, struggling against illness, poverty, and alcoholism.

Some of Foster's songs became so popular during his lifetime that they were adapted (with suitable words) for Sunday school use. The American composer Charles Ives often quoted Foster's tunes in his own music when he wanted a real American flavour. Foster's songs are deeply rooted in American folk tradition, and many of them have become part of the American cultural heritage.

Foster parent is a person who provides a home for one or more children who are not legally members of his or her family. Most foster parents have children of their own.

Most foster parents care for children under the supervision of a public or private social agency that has the basic responsibility for the youngsters. Such agencies find foster parents for children whose natural parents cannot provide adequate care. In some cases, the natural parents abused, deserted, or neglected the children. In others, the parents suffer from long-term mental or physical illness. The separation from the natural family and the adjustment to a foster family can be an unpleasant experience for a child. Foster parents try to provide a family environment that will encourage the child to grow up normally.

Foster parents, natural parents, and social agencies work together in planning the care of each child. Some children remain in foster homes until they reach adulthood. But many foster children are returned to their natural homes after their natural parents become capable of caring for them. Social agencies find adoptive homes for other foster children.

Government requirements for foster parents include good health, adequate housing, and certain qualities of personality and family life. Social workers monitor both the foster parents, and the children placed in their care. Social agencies generally pay for part of the clothing, food, and medical care required by foster children under their supervision.

See also **Adoption**.

Foucault, Jean Bernard Léon (1819-1868), a French physicist, used a revolving mirror to measure the speed of light. Some types of measuring apparatus still use adaptations of his method. Foucault proved in 1850 that light travels more slowly in water than in air, and that the speed varies inversely with the index of refraction. He also made improvements in the mirrors of reflecting telescopes.

Foucault demonstrated the rotation of the earth on its axis with a pendulum experiment, and also by using a gyroscope that maintained its axis in a fixed direction while the earth turned relative to that direction (see **Gyroscope; Pendulum** [picture: A Foucault pendulum]). He also discovered the existence of eddy currents, which are produced in a conductor moving in a magnetic field. Foucault was born in Paris.

Foundation. See **Building construction; House.**

Foundation Day is an annual public holiday in Western Australia. It celebrates the arrival from England in 1829 of James Stirling and the first party of settlers in the transport ship *Parmelia.* They founded the Swan River settlement, the first settlement in what is now the state of Western Australia. Foundation Day is actually June 1, but the holiday is held on the first Monday in June. The main activities are a flag-raising ceremony at Fremantle and a pioneers' memorial service in the historic East Perth cemetery on the preceding Sunday.

Foundry is a plant where workers make moulded metal products called *castings.* Products made in foundries range from engine blocks to toy soldiers. The process of pouring melted metals into moulds is called *founding.* The metals commonly used are iron, steel, brass, bronze, aluminium, lead, zinc, and magnesium (see **Cast and casting**). Dies can also be made in foundries (see **Die and diemaking**).

Foundries that turn out heavy castings often do their founding in large pits in the floor. Overhead cranes ease the work of lifting and carrying the heavy moulds and castings from place to place. Some foundries are highly automated. In such foundries, machines make the moulds, pour the metal, and clean the castings.

See also **Forging; Heat** (picture: People use heat).

A fountain at the Palace of Versailles, near Paris, is one of several beautiful fountains in the palace grounds. Begun in 1661, the Versailles fountains had elaborate pumping systems that were characteristic of many fountains built in Europe from the 1500's to the 1700's.

Fountain is a jet or stream of water that rises naturally or artificially as a result of pressure. In a natural fountain, this pressure comes from the weight of water collected in a reservoir, from its temperature, or from both. The water flows through an underground passage until it can discharge, as in a spring, or shoot out, as in a geyser. In artificial fountains, pumps supply the pressure. This article deals with artificial fountains.

Artificial fountains can be both decorative and practical. They help keep pools and ponds clean and can reduce excess flow of water. Decorative fountains are frequently found in squares, parks, and shopping centres. In such fountains, water may flow from or over sculptures of people, mythical creatures, or natural objects. People enjoy watching and hearing the water's movement. Some decorative fountains are illuminated by coloured lights.

Fountains have existed for thousands of years. In ancient Greece, people built fountains above springs thought to have magical powers. The Greeks added beautiful statues of Greek gods and goddesses to the flowing waters. The ancient Romans built hundreds of fountains in Rome, copying Greek designs.

Some of the most complicated and beautiful fountains in Europe were built during the Renaissance and baroque periods, from the 1500's to the 1700's. Elaborate pumping systems created wide cascades of water, channelled water down steps, or forced it to shoot up in powerful jets. Many famous fountains were built during the 1600's and 1700's. These include the Fountain of the Four Rivers (1651) and the Trevi Fountain (1762), both in Rome. The fountains at the Palace of Versailles (begun in 1661), near Paris, are also well known.

During the late 1800's and early 1900's, purely ornamental fountains continued to be popular as focal points for civic design in large cities. Today, architects use computers to control lights and water flow in many public fountains. These fountains can sometimes be as elaborate and beautiful as those of any previous era.

See also **Artesian well; Geyser; Rome** (picture: Rome's Piazza Navona); **Taft, Lorado** (picture); **Versailles** (picture).

Fountain of Castalia. See **Parnassus.**

Fountain of Youth was an imaginary spring. Many legends were told about it in both Europe and America. Its waters were supposed to make old people young, and to heal all kinds of sickness. Tribes of Indians in Central America and the West Indies thought the spring was in the Bahama Islands. Spanish explorers searched for it throughout the area. Juan Ponce de Leon searched for the fountain in Florida, U.S.A., but he never found it. A spring in St. Augustine, Florida, is marked today as one that he discovered.

See also **Ponce de León, Juan** (Early career).

Fountain pen. See **Pen.**

Four-eyed fish. See **Anableps.**

Four Horsemen of the Apocalypse are beings mentioned in the sixth chapter of the last book of the New Testament of the Bible, The Revelation of St. John the Divine. The chapter tells of a scroll in God's right hand that is sealed with seven seals. When the first four of these seals are opened, four horsemen appear. Their horses are white, red, black, and pale (literally, greenish-yellow). The horsemen represent various hardships that the human race must endure before the end of the world, specifically Conquest, War, Famine, and Death.

Woodcut (about 1496) by Albrecht Dürer; the Metropolitan Museum of Art, New York City

The Four Horsemen of the Apocalypse symbolize the forces of destruction and war in the New Testament Book of Revelation. They represent Conquest, War, Famine, and Death.

The four horsemen are often featured in art and literature. The German artist Albrecht Dürer included a picture of them in a series of woodcuts illustrating the Book of Revelation.

Four Masters were four Irish scholars who, in the early 1600's, compiled manuscripts on Irish history. These scholars were Michael O'Clery, Peregrine O'Clery, Fearfeasa O'Mulconry and Peregrine O'Duigenan. Their main work was a chronological history of Ireland called the *Annals of the Kingdom of Ireland* or the *Annals of the Four Masters.*

The Four Masters were lay brothers of the Franciscan Order. They spent four years, from 1632 until 1636, compiling the annals in a Franciscan convent at Donegal, in Ireland.

Michael O'Clery (1575-1643) was the most eminent of the Four Masters. He was a member of a family that had been professional historians to the O'Donnell chieftains for generations. O'Clery became a lay brother in the Franciscan monastery at Leuven, in Belgium. His superiors sent him to Ireland to collect and transcribe manuscripts on Irish history, with special reference to Ulster.

Four-o'clock, also called the *marvel-of-Peru,* is an attractive *perennial* (plant that lives for more than one year) from tropical America. It is easy to grow, and is often cultivated as an *annual* (plant that lives for only one year). The four-o'clock grows from about 60 to 120 centimetres high. It has fragrant flowers that may be white, pink, red, yellow, or a mixture of several of these colours. What seem to be the flowers are actually colourful *involucres* (modified bracts) surrounding the tiny true flowers. The four-o'clock gets its name from the fact that the plant's flowers open late in the afternoon and close in the morning.

The four-o'clock grows well in almost any kind of soil. The plant can be started from seeds, or from its roots, saved for planting in the spring. The four-o'clock makes an attractive, bushy border plant.

Scientific classification. The four-o'clock is in the four-o'clock family, Nyctaginaceae. It is *Mirabilis jalapa.*

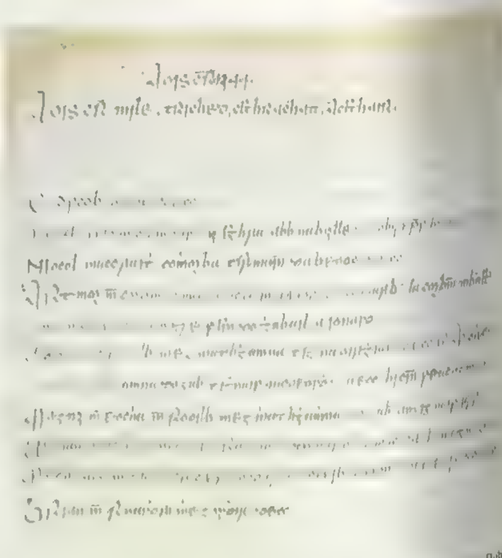
See also Flower (picture: Flowers of the desert).

Fourdrinier machine. See Paper (How paper is made).

Fourier, Charles (1772-1837), was an important French socialist. He criticized the social conditions of his times, and believed that society could be improved if private property were eliminated.

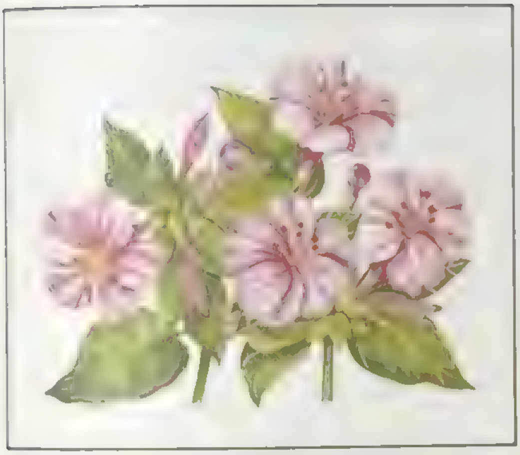
Fourier thought conditions could be improved through an economic and social regrouping of people. He wanted to create small, self-sufficient farm communities of about 1,600 people each. Each person would own a share of the property in these communities. All people in the community would be required to work, but they could choose their own type of work. Fourier's ideas attracted many followers. However, he could not put together enough money to start such a venture. Fourier was born François Marie Charles Fourier in Besançon, France.

Fourth dimension. We usually think of space as having three dimensions: length, width, and height. A box that is 6 metres long, 4 metres wide, and 2 metres high can be described by the ordered set of numbers (6,4,2). Such a set may also be used to describe the position of a point in space—for example, the position of an aeroplane. But three numbers cannot represent the location



Royal Irish Academy, Dublin

The *Annals of the Four Masters,* an Irish historical manuscript, was written in the 1630's by four monks at Donegal.



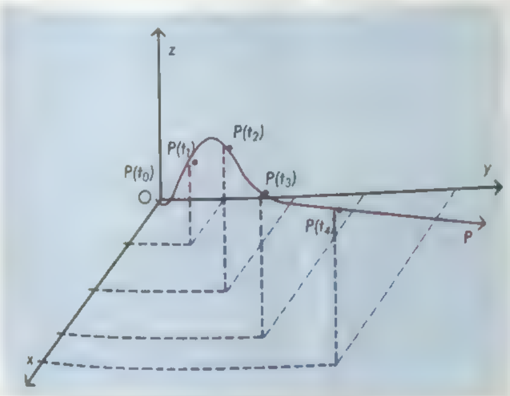
The four-o'clock has colourful, fragrant flowers.

of a *moving* plane. To indicate when a plane in flight is at a particular location, such as (6,4,2), we need a fourth dimension—time.

The path of a flying aeroplane can be plotted in four dimensions as shown in the graph, where the plane takes off from point *O* and travels southeast. The position on the *x*-axis shows its distance south of point *O;* the position on the *y*-axis, its distance east of point *O;* and the position on the *z*-axis, its altitude. Curve *P* represents the path of the plane through space. The points along curve *P* indicate the location of the plane at four different times, called t_0 to t_4.

The fourth dimension need not always represent time, however. It may represent anything that we can measure, including temperature and weight.

In the early 1900's, the mathematician Hermann Minkowski realized that the special relativity theory proposed by physicist Albert Einstein described a universe with four dimensions. According to Minkowski, time combines with the three dimensions of space to form *space-time.* Mathematicians afterward began to study geometries of four or more dimensions. See **Relativity.**



Graphical representation of the path of a flying aeroplane in four dimensions.

Fourth estate is a name sometimes given to the newspaper profession in England. Among the members of the fourth estate are those who gather, write, and edit the news for the press. The phrase *fourth estate* is believed to have first been used by the English historian Thomas Babington Macaulay. In 1828, he wrote with reference to the press gallery of the House of Commons, "The gallery in which the reporters sit has become a fourth estate of the realm."

Macaulay was adding a term to those already used for the three estates, or classes, of the English realm. These were lords spiritual, lords temporal, and commons. The three estates later came to stand for government, while reference to a fourth estate described any other influential body in English political life, such as the army or the press.

Fourth Republic. See France (History; Government).

Fovea centralis. See Eye (Focusing; diagram: Parts of the eye).

Fowl. See Poultry; Chicken.

Fowler is the family name of two brothers who became *lexicographers* (dictionary makers) and writers. They were born at Tonbridge, in Kent, England.

Francis George Fowler (1870-1918) collaborated with his brother on *The King's English,* a guide to English grammar and usage published in 1906. In 1911, they published the *Concise Oxford Dictionary,* an abridgement of the *Oxford English Dictionary.*

Henry Watson Fowler (1858-1933) is famous for his *Dictionary of Modern English Usage,* which was published in 1926. This masterly guide to correct English usage was scholarly but entertaining, and an instant success. Henry planned it in collaboration with his brother, but Francis died before they had begun the actual writing. Sir Ernest Gowers revised the book in 1965. Henry Fowler was educated at Rugby School, Warwickshire, England, and Oxford University. From 1882 to 1899, he was a schoolmaster at Sedbergh School, in Cumbria, England. The two brothers then lived in Guernsey, in the Channel Islands.

Fowler, Sir John (1817-1898), a British engineer, built with Sir Benjamin Baker the Forth Rail Bridge, in Scotland. Fowler was engineer of the Stockton-Hartlepool Railway. His many railways in England include the Metropolitan Railway in London. He designed the Pimlico Railway Bridge, in London. Fowler was born near Sheffield, England.

Fowler, Sir Norman (1938-), an English politician, became chairman of the Conservative party in 1992. He was secretary of state for employment from June 1987 until January 1990. He had been a Cabinet minister since 1981, serving as minister of transport from 1979 to 1981, secretary of state for transport from January to September 1981, and then as secretary of social services until 1987.

Peter Norman Fowler was educated in Chelmsford, Essex, and at Trinity Hall, Cambridge. He worked as a journalist with *The Times* from 1964 until 1970.

Fox is a bushy-tailed, sharp-snouted member of the dog family. True foxes include the arctic fox, the grey fox, and the red fox. Foxes live throughout the world, except in Antarctica and Southeast Asia and on some islands. They may be found in farmlands and forests, in deserts, and even in wooded areas of some cities and suburbs.

The grey fox is the only member of the dog family that frequently climbs trees. It may scamper into the branches to escape an enemy or, apparently, for no reason at all.

The red fox, in particular, has invaded urban areas of Britain. It scavenges for food from domestic waste, and from refuse put out by shops and restaurants.

Foxes are quick, skilful hunters. The red fox can easily catch a dodging rabbit. This fox can also creep silently toward a bird, then rush up and pounce on it.

The arctic fox and the red fox, have long, soft fur that is valued highly. People trap foxes for their fur and also raise the animals on fur farms (see Fur).

Some people hunt the red fox because of its skill in trying to avoid capture. Many hunters seek only the excitement of the chase and do not kill the fox. The hunters use hounds to follow the scent of the fox. But the fox may double back on its trail or run into water, making its scent difficult to follow.

Most foxes are about 60 to 70 centimetres long plus a 35 to 40 centimetre long tail, and weigh about 5 to 7 kilograms.

Facts in brief

Names: *Male,* dog; *female,* vixen; *young,* cub or pup.
Gestation period: 49 to 79 days, depending on species.
Length of life: Up to 14 years.
Where found: Throughout the world except Antarctica, Southeast Asia, and some islands.
Scientific classification: Foxes belong to the dog family, Canidae. The arctic fox is *Alopex lagopus;* the bat-eared fox is *Otocyon megalotis.* The fennec is *Vulpes zerda;* the grey fox is *V. cinereoargenteus,* the kit fox is *V. macrotis;* the Eurasian red fox is *V. fulva;* the North American red fox is *V. vulpes.*

The body of a fox

Most species of foxes resemble small, slender dogs. But unlike most dogs, foxes have a bushy tail. Foxes also have large, pointed ears and a long, sharp snout.

A fox has keen hearing and an excellent sense of smell. It depends especially on these two senses in locating prey. A red fox can hear a mouse squeak over 30 metres away. Foxes quickly see moving objects, but they might not notice objects that are motionless.

A fox has four toes and a toelike *dewclaw* on each front foot. The animal's dewclaw is actually a nonmovable thumb and does not reach the ground. Each hind foot has only four toes. When a fox walks or trots, its hind paws step into the tracks of the front paws.

Most foxes carry their tails straight backward when running. The tail droops when the animal walks. A fox may sleep with its tail over its nose and front paws. Many foxes have a scent gland on the tail. Scent from this gland gives foxes a distinctive odour.

The life of a fox

Most knowledge about foxes comes from studies of the red fox. The information in this section refers mostly to the red fox, but other species of foxes do not differ greatly.

Foxes live in family groups while the young are growing up. At other times, they live alone or in pairs. They do not form packs as wolves do. A male and a female mate in early winter. They play together and cooperate in hunting. If one of a pair of foxes is chased by an

Red foxes live in family groups. An adult male and female, *above,* stay together after mating until their young mature. The same pair may mate year after year. The eyes of all fox cubs, *right,* do not open until about nine days after the animals are born.

Dens of various kinds of foxes may be underground, in a hollow log or tree, in a cave, or among rocks. Red foxes enlarge burrows of other animals, or dig their own dens.

enemy, its mate may dash out of a hiding place and lead the pursuers astray.

Foxes communicate with one another with growls, yelps, and short yapping barks. A fox also makes *scent stations* by urinating at various spots. The scent stations tell foxes in the area that another fox is present.

Young. A female fox gives birth to her young in late winter or early spring. A young fox is usually called a *cub* or *pup*. Red foxes have from four to nine cubs at a time, and grey foxes have from three to five. Both the *vixen* (female) and the *dog* (male) bring their cubs food and lead enemies away from them.

A newborn fox weighs about 110 grams and has a short muzzle and closed eyes. Its eyes open about nine days after birth. Cubs drink the mother's milk for about five weeks. Then they begin to eat some solid food and leave their den for short periods. Later, the cubs wrestle with one another and pounce on insects, leaves, sticks, and their parents' tails. The adults also bring live mice for the young to pounce on. Later, the adults show the young how to stalk prey. The cubs start to live on their own in late summer and may wander far from their place of birth. The parents may separate then or in early autumn and get back together during the winter.

Dens. Foxes settle in dens after mating. A fox den may be underground, in a cave, among rocks, or in a hollow log or tree. Some foxes dig their own dens, others use burrows abandoned by such animals as badgers. The foxes may enlarge a burrow if necessary. An underground den may be over 20 metres long and have several entrances. A main tunnel leads to several chambers that the animals use for nests and for storing food. Two pairs of red foxes may share one burrow.

Many kinds of foxes live in dens only while raising their young. After the cubs have grown old enough to hunt for themselves, the adults and the cubs both sleep in the open most of the time.

Food. Foxes eat almost any animal they can catch easily, especially mice and other kinds of rodents. They also hunt birds, frogs, insects, lizards, and rabbits. Foxes also eat many kinds of fruit and the remains of dead animals. Most species hide the uneaten parts of their prey. They dig a shallow hole, drop the meat in, and cover it with earth. A fox returns to the stored food, both to feed and, apparently, to check on it.

Foxes may prey on farmers' chickens if the birds roam freely or if the chicken coops are not closed tightly. But foxes help farmers by eating mice and rats. In some areas where foxes had been killed off, rodents increased so much that farmers brought in other foxes.

Hunting. Foxes hunt mostly at night and remain active throughout the year. They often roam grassy meadows and listen for the squeaks of mice. The grass conceals the mice, but if a fox sees a slight movement of blades of grass, it jumps onto the spot. Foxes sometimes stand on their hind legs to get a better view in tall grass. A fox also may lie in wait and pounce on a vole or ground squirrel as the victim leaves its burrow.

Kinds of foxes

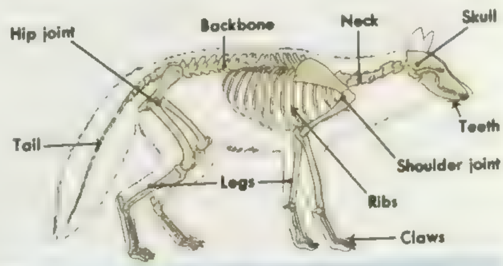
Arctic fox lives in the far northern regions of Asia, Europe, and North America. The long fur of the arctic fox's coat protects the animal from the extreme cold. The arctic fox has shorter, more rounded ears than most other foxes. These small ears let less body heat escape than larger ears would. See **Arctic fox**.

Bat-eared fox, also called *big-eared fox,* lives in dry areas of eastern and southern Africa. A bat-eared fox has large ears. It has a grey-brown back and sandy underparts. Bat-eared foxes feed mostly on insects, especially termites. They also eat fruit and such rodents as mice and rats. Bat-eared foxes can change direction sharply while running at full speed, and this ability helps them overcome small fast-footed prey.

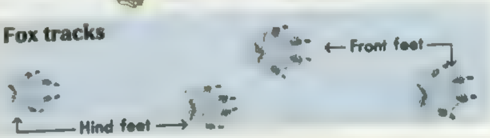
Fennec, the smallest kind of fox, lives in the deserts of North Africa and Arabia. A fennec grows only about 40 centimetres long and weighs about 1 to 1.5 kilograms. It has pale sandy fur with whitish underparts. Its ears are 10 to 15 centimetres long. Fennecs have a large surface area through which they can lose body heat to keep from becoming overheated. See **Fennec**.

Grey fox lives in southern Canada, the United States, Mexico, Central America, and northern South America. It is the most common fox of the Southern United States. The grey fox's back is the colour of salt and pepper mixed together. Its underparts are whitish. The sides of the neck, shoulders, legs, and the tail's underside are rust-coloured. The tail has a black tip. This fox is also called the *tree fox* because it climbs trees.

The skeleton of a fox



Fox tracks



The Arctic fox lives in the polar region of the Arctic Ocean. Its long fur coat protects the animal from the extreme cold. The fur turns from brown or grey in summer to white in winter.

The bat-eared fox has large ears. It lives in areas of eastern and southern Africa.

Kit fox, also called *swift fox,* roams the grasslands and deserts of western North America. It has sandy yellow-grey fur with a black tip on the tail. This fox, a close relative of the red fox, measures from about 38 to 50 centimetres long, not including a 28 centimetre-long tail. It got its name because its size is like that of a kitten. It is a fast runner, reaching speeds of up to 40 kilometres per hour. Kit foxes are active at night.

Red fox lives throughout most of Asia, Europe, and northern North America. Red foxes were originally introduced into Australia in the 1850's to be hunted for sport. They proved to be a pest because they preyed mainly on small native marsupial mammals.

The majority of red foxes have bright rusty-red or red-orange fur, with whitish fur on the belly. They have blackish legs and a white tip on the tail. But not all red foxes have red coats. Some, called *silver foxes,* have coats of black fur tipped with white. Silver foxes may appear blackish, grey, or frosty silver, depending on the length of the white tips. Silver foxes with black fur are called *black foxes.* Other red foxes, called *cross foxes,* have rusty-red coats with a large black cross at the shoulders. The cross extends down the middle of the back. Silver foxes, cross foxes, and typical red foxes may be born at the same time to the same parents.

Other foxes include the *Bengal fox* of southern Asia, and the *Corsac fox* of the Eurasian steppes.

Fox, Charles James (1749-1806), an English statesman and speaker, was a friend of the American Colonies in their fight for freedom from Britain. He also defended the French Revolution when most British leaders, including Edmund Burke, opposed it. He was sympathetic, had a warm personality, and was an eloquent speaker.

Fox was born in Westminster, London. In 1768, he entered the British Parliament as a Tory, but later joined the Whig Party. Because of his support in Parliament of the American Colonies during the American Revolution, King George III became his enemy. His career was also disturbed by the opposition of William Pitt. Fox had a major role in the preliminaries of the impeachment of Warren Hastings (see **Hastings, Warren**). Fox became England's secretary for foreign affairs in 1806.

Fox, George (1624-1691), an English religious leader, founded the Society of Friends, or Quakers, in about 1647. He taught that the presence of the "Inner Light" in the individual should guide that person's faith and actions. His followers were first called *Quakers* because Fox once told a British judge "to tremble at the word of the Lord." See **Quakers**.

Lithograph by Leopold Grozelier

George Fox

As a young man, Fox believed that he had received a divine call, and began going from place to place preaching his ideas of religion. Fox advised people to give up their worldly pleasures. He was imprisoned several times for his teachings. Fox made missionary journeys through Ireland, Scotland, the West Indies, North America, and the Netherlands, and attracted many followers. He was born in Leicestershire, England.

Fox, Sir William (1812-1893), was four times premier of New Zealand. He first became premier in 1856, but only for two weeks. He later served in 1861 and 1862, from 1869 to 1872, and briefly in 1873. Fox strongly opposed moves to abolish the country's system of provincial government. He was born at Westoe, near South Shields, Durham, in England. He emigrated to New Zealand in 1842 and entered politics in 1855.

Fox hunting, also called *riding to hounds,* is a sport that originated in England in about the middle 1700's. The sport consists of finding a wild fox, and hunting it by scent with a pack of hounds especially trained for the purpose. The fox hunters, mounted on horses, follow the hounds across the countryside. This group of mounted followers is called the *field.* It is led by the *master of foxhounds.* The pack of hounds is managed in the hunting field by the *huntsman.*

The first packs of hounds used only for fox hunting were established in England. English settlers introduced the sport to Australia, New Zealand, and North America.

See also **English foxhound.**

Fox Talbot, William Henry (1800-1877), was a British scientist who invented the negative-positive system in photography.

Fox Talbot was born in Lacock, Wiltshire, England, and educated at Harrow School and Cambridge Univer-

sity. He entered British Parliament in 1833 but resigned a year later. By 1835, he had devised the negative-positive system, on which photography is still based. In 1840, after exploring the light sensitivities of silver-based chemicals, Fox Talbot produced an image that could be printed on silver chloride paper.

Between 1844 and 1846, Fox Talbot published *The Pencil of Nature,* the first book to be illustrated with photographs. He later did pioneer work in high-speed photography, and etching with photographs. Fox Talbot was also an accomplished mathematician.

Fox terrier. See **Smooth fox terrier; Wire fox terrier.**

Fox trot is a ballroom dance that first became popular in the United States in about 1914. The dance combined slow, gliding walking steps with fast walking steps. At first, the dance was performed to ragtime. Its special quality was created by *syncopation* (accenting normally unaccented beats). Later, people danced the fox trot to any popular tune in $\frac{4}{4}$ time.

The fox trot probably got its name from Harry Fox, a vaudeville performer. Fox performed a frantic trotting dance in a vaudeville show. Ballroom dancers adopted and modified the steps into a smoother, less jerky dance for couples. At first, the fox trot was danced to very fast music, but it later became much slower. The fox trot was very popular in the 1920's and influenced the Charleston and other ballroom dances.

Foxe, John (1516-1587), an English Puritan teacher, was the author of the *Book of Martyrs* (1563). This work, originally entitled *Actes and Monuments,* was popular for many years after its publication. Its theme is the suffering of Christian martyrs, particularly of the Protestant martyrs of Queen Mary's reign. Foxe was born at Boston, in Lincolnshire, England, and educated at Oxford University. He was a Fellow of Magdalen College, Oxford, until he resigned for religious reasons in 1545 and left England. He returned to England in 1560.

Foxfire. See **Will-o'-the-wisp.**

Foxglove is the name for a group of plants native to Europe, northern Africa, and western and central Asia. The foxglove gets its name from its flowers, which are shaped somewhat like fingers of a glove. The leaves of the purple foxglove and the Grecian foxglove contain a powerful poison used to make the drug *digitalis.* In rare cases, children and animals have died from this poison after eating foxgloves. Doctors use small amounts of digitalis to treat certain heart diseases (see **Digitalis**).

The foxglove produces richly coloured flowers. The bell-shaped blossoms grow in a cluster along one side of the stem.

Oil painting on wood panel. National Gallery of Art, Washington, D.C.

The *Madonna of Humility* by Fra Angelico shows the artist's skill in combining delicate colours with simple, graceful figures.

The foxglove grows from 60 to 150 centimetres tall. The long oval leaves grow along the stem. The bell-shaped flowers are purple, pink, lilac, yellow, or white—the deeper-coloured ones more or less spotted. They grow along one side of a wandlike cluster. The plants are biennials or short-lived perennials, usually dying after the second season. New seed should be planted yearly for continual bloom. Foxgloves grow best in soil that keeps some moisture.

Scientific classification. The foxglove belongs to the figwort family, Scrophulariaceae. The purple foxglove is *Digitalis purpurea.* The Grecian foxglove is *D. lanata.*

See also **Superstition** (The role of superstitions).

Foxhound is a medium-sized hound. Packs of hounds hunt foxes by following their scent on the ground. There are two distinct breeds, American and English. See **American foxhound; English foxhound.**

Fra Angelico (1400?-1455) was an Italian painter. He helped pioneer Renaissance methods of art in the city of Florence, Italy. His strong, plain figures in measured space reflected the newer ideas of his time, but he continued to use the bright, unshadowed colours that were traditional. He had many imitators who added sentimental flavour to his style. Such work has been credited to him.

Fra Angelico was a Dominican friar. When the great new monastery of San Marco in Florence was established in about 1435, he became a member and remained one until his death. He covered the walls of the monastery with religious images. Many of Fra Angelico's other paintings are now collected at the monastery as a museum of the artist's work. One of his paintings, *The Annunciation,* appears in the **Painting** article. Fra Angelico's other works include *The Coronation of the Virgin* and *The Nativity.*

Fra Angelico was born in Vecchio, Italy. He became a monk in Fiesole when he was 19, and was known as Fra Giovanni da Fiesole. Later, his admirers called him Fra Angelico (angelic brother).

See also **Aquinas, Saint Thomas** (picture).

Fractal is a complex geometric figure made up of patterns that repeat themselves at increasingly smaller scales. The existence of these repeating patterns is called *self-similarity* and is an important property of fractals. A geometric figure has this property when the shape of one of its smaller structures is similar in shape to a larger structure, which in turn is similar to an even larger one, and so on.

Fractals represent mathematical equations. Scientists are interested in the fact that very simple equations can give rise to such complex patterns. Fractals have helped investigators to demonstrate the regular underlying features of many processes found in nature. An example of a fractal found in nature is the shape of a fern. Each fern consists of leaflets that have the shape of the fern itself, and each leaflet in turn is made up of smaller leaflets that again have the same shape as the fern. Many other plants, including cauliflower and broccoli, have a fractal structure. The structure of the blood vessels of the heart is also that of a fractal: large vessels branch into smaller ones that in turn branch into even smaller vessels.

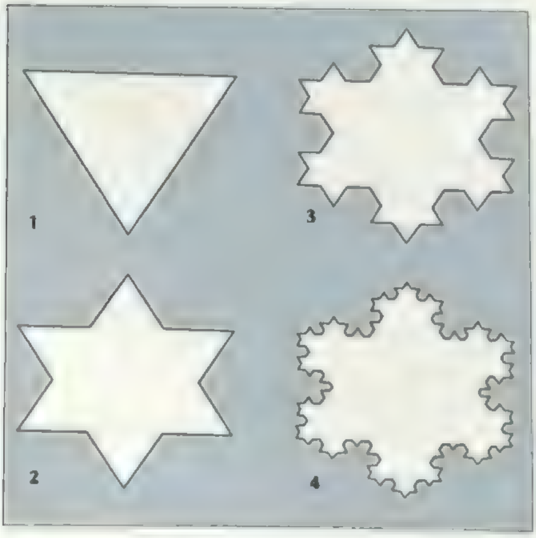
There are two main types of fractals—*regular fractals* and *random fractals.* Regular fractals, also called *geometric fractals,* consist of large and small structures that, except for their size, are exact copies of each other. For example, a regular fractal known as the *Koch snowflake* is made up entirely of small triangles added to the sides of larger triangles.

In random fractals, the large-scale and small-scale structures are mathematically related, but may differ in detail. Many random fractals represent irregular patterns found in nature. For example, the shapes of coastlines, mountains, and clouds can be represented by random fractals.

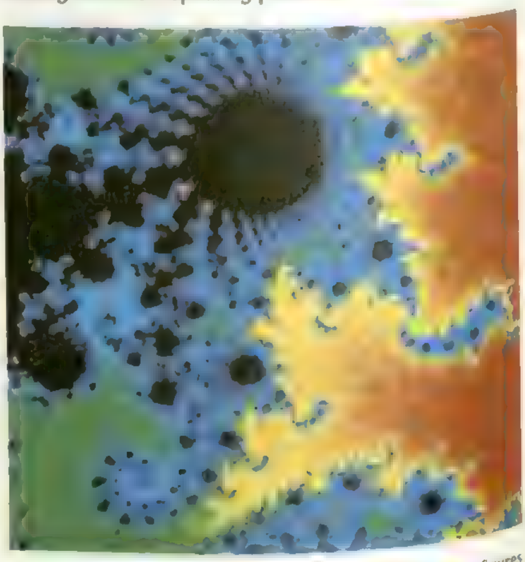
Many phenomena are fractal in nature. For example, *Brownian motion*—the random motion of a particle suspended in a fluid—can be represented by a random fractal. Other examples are the growth of plants, the paths followed by lightning, and *viscous fingering*—the diffusion of one liquid into another in which it cannot dissolve, such as oil in water.

The German mathematicians Georg Cantor and Karl Weierstrass, working in the 1800's, investigated sets of curves with self-similar properties. But for many years this work received little attention. Interest revived in the late 1960's, particularly in the work of Benoit Mandelbrot, a Polish-born mathematician who settled in the United States in 1958. Mandelbrot coined the term *fractal* in 1975. He derived the term from the Latin word *fractus,* which indicates a broken stone with an irregular surface. He became interested in the subject during a study of Britain's coastline.

Mathematicians have studied mathematical functions whose graphical representations form fractals. One of the best known of these is the *Mandelbrot set,* which Mandelbrot and others have been investigating since the late 1970's. Scientists use computers for its graphical representation because it requires a very large number of calculations. The complete set forms a complex pattern known as the "ink splash." The computer can "magnify" sections of the Mandelbrot set by representing it over increasingly smaller boundaries, revealing an unending series of repeating patterns.



A Koch snowflake is a fractal that is formed by adding small triangles to the sides of larger triangles. The diagram above shows the formation of a Koch snowflake in four steps



A complex pattern of geometric fractals results from figures that repeat themselves endlessly at a smaller and smaller scale A supercomputer produced this colourful image

Students learn to add fractions. The four basic operations of arithmetic—addition, subtraction, multiplication, and division—can all be performed using fractions.

Fraction

Fraction is a part of something. When objects are measured, often the measurements do not come out in whole units. A book may weigh between 2 and 3 kilograms. The amount over 2 kilograms is a fraction of a kilogram. A board may measure between 10 and 11 centimetres long. It is 10 centimetres plus a fraction of a centimetre long. The word *fraction* comes from *frangere*, a Latin word meaning *to break*. Fractions result from breaking a unit up into a number of equal parts. A unit can be broken into any number of parts. If you break a stick into two pieces, however, you do not necessarily have two halves of the stick. In order to have two halves of the stick, you must break it into two pieces of equal length.

Fractions are written in numerical form as two numerals separated by a line.

$$\frac{2}{5} \text{ or } 2/5$$

In arithmetic, a fraction generally stands for the number of equal parts into which something has been divided and the number of those parts that are being considered. For example, the fraction $\frac{2}{5}$ represents two parts of something that has been divided into five equal parts.

The fraction form is also used for (1) expressing division, (2) representing a ratio, and (3) stating a rate. In expressing division, the fraction $\frac{2}{5}$ may indicate two divided by five—for example, dividing two chocolate bars equally among five people. A ratio is a comparison of two quantities that are both measured in the same units. A ratio may compare a part to a whole or a part to another part. For example, if there are two girls and three boys on a debating team, the ratio of girls (a part) to team members (the whole) is two to five ($\frac{2}{5}$). The ratio of girls (a part) to boys (another part) on the team is two to three ($\frac{2}{3}$). In mathematics, any number that can be written as the ratio of two whole numbers is called a *rational number* (see **Ratio**). *Irrational numbers* cannot be written as a ratio of two whole numbers. Pi, which is defined as the ratio of the circumference of a circle to its diameter, is an irrational number. However, the fraction $\frac{22}{7}$ gives an approximation of the value of pi and can be used in calculations (see **Pi**). Rate is the relation between two quantities that are measured in different units. For example, a basketball team may score at the rate of two goals per every five minutes of play.

The different uses and meanings of fractions are closely related. Often, understanding one of the meanings of fractions will help make understanding other uses easier. This article concentrates on the meaning of fractions as parts of a whole and examines the use of fractions in arithmetic.

Expressing fractions

In words. The names for fractions come from the number of equal parts into which a whole unit has been divided. In English, there are special names for the fractional parts formed when a unit is divided into two, three, or four equal parts. When a unit is broken into two equal parts, each part is called a half. When it is broken into three equal parts, each part is called a third. And when it is broken into four equal parts, each part is called a quarter or a fourth. The names for other fractional parts are made by adding *-th* to the end of the

Fraction terms

Cancellation involves dividing a numerator and a denominator by the same number.
Common, in arithmetic, means *shared* or *the same.* Fractions with the same denominator, such as $\frac{1}{5}$ and $\frac{4}{5}$, have a *common denominator.*
Complex fraction has a fraction in its numerator, its denominator, or both. The fraction $\frac{\frac{7}{12}}{\frac{3}{4}}$ is a complex fraction.
Converting a fraction means changing its form but not its value. For example, $\frac{5}{6}$ can be converted to $\frac{10}{12}$ by multiplying both the numerator and the denominator by two: $\frac{5}{6} \times \frac{2}{2} = \frac{10}{12}$. The fraction $\frac{2}{2}$ is a form of one.
Decimal fractions have denominators of 10 or of 10 multiplied by itself a number of times.
Denominator is the number written below the line in a fraction. In the fraction $\frac{2}{3}$, the denominator is 3. The denominator tells into how many parts a whole has been divided.
Equivalent fractions have different numerators and denominators, but still express the same part of a whole. For example, the fractions $\frac{1}{2}$ and $\frac{2}{4}$ are equivalent.
Improper fraction has a numerator that is equal to, or larger than, the denominator. For example, $\frac{4}{4}$ and $\frac{5}{4}$ are improper fractions.
Mixed number is a combination of a fraction and a whole number. For example, $2\frac{1}{4}$ is a mixed number.
Numerator is the number written above the line in a fraction. In the fraction $\frac{2}{3}$, the numerator is 2. The numerator tells how many parts are being considered.
Proper fraction is a fraction whose numerator is smaller than its denominator. For example, $\frac{3}{4}$ is a proper fraction, because 3 is smaller than 4.
Reducing a fraction means converting it to an equivalent fraction with a smaller numerator and denominator. But the new fraction has the same value as the old.
Term refers to either the numerator or the denominator of a fraction.
Value of a fraction is the number that the fraction stands for. Equivalent fractions, such as $\frac{2}{3}$ and $\frac{4}{6}$, have the same value and stand for the same number.

word that tells the number of equal parts into which the unit has been broken. For example, the fractional parts made by breaking a kilometre into 10 equal parts are called *tenths* of a kilometre.

As a unit is broken into more and more equal parts, each part gets smaller and smaller. If a unit is broken into six equal parts, each part is a sixth. If the same unit were broken into 12 equal parts, each part would be a twelfth. Although a twelfth may sound larger than a sixth, each twelfth is only half as big as each sixth. The larger-sounding fraction name means that the original unit has been broken into more—and thus smaller—parts.

The number word before the fraction name tells how many of the fractional parts are being considered. For example, five-sixths represents five of the sixths into which something has been broken. Six-sixths means that a unit has been divided into six equal parts, and all six parts are being considered. Therefore, six-sixths equals one whole unit. Similarly, seven-sevenths, eight-eighths, nine-ninths, and so on all equal one.

In symbols. When fractions are written in numerical form, the bottom, or second, numeral is called the *denominator* (namer). It provides the name of the fraction, telling the number of equal parts into which the unit has been broken. The top, or first, numeral is called the *numerator* (numberer). It tells how many of the fractional parts are being considered. The numerator and the denominator are called the *terms* of a fraction.

Fractions such as $\frac{4}{10}$, $\frac{7}{100}$, and $\frac{5}{1{,}000}$ are called *decimal fractions.* Decimal fractions have denominators of 10 or 10 multiplied by itself a number of times. Decimal fractions can be written without a denominator by using the decimal system. In this system, the value of each decimal place in a figure is 10 times smaller than that of the place to its left. For example, the first place to the right of the decimal point is the $\frac{1}{10}$'s (tenths) place. The second place to the right of the decimal point is the $\frac{1}{100}$'s (hundredths) place. When using the decimal system, the number of parts into which the unit has been divided is indicated by the number of decimal places used. The numerals that are in the decimal places used represent the number of parts that are being considered. For example, the fraction $\frac{7}{10}$ may be written as 0.7 in the decimal system. Twenty-seven hundredths is written as 0.27. For information on changing fractions to decimals and changing decimals to fractions, see **Decimal system** (Decimals and fractions).

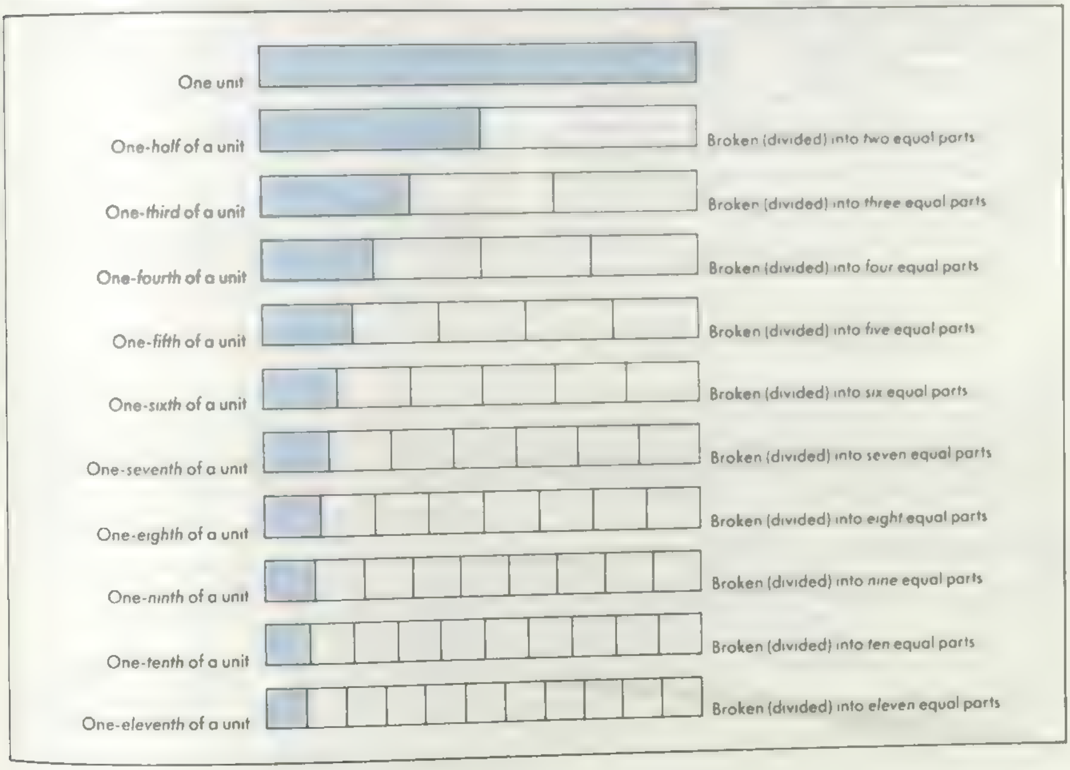
Equivalent fractions

When two fractions have different numerators and denominators but still express the same part of a whole,

Different meanings of the fraction notation $\frac{2}{5}$

Kind of meaning	Meaning:	Words for fraction notation
Fractional part	*One* (of something) broken into *five* equal parts and then *two* of the parts taken	two-fifths
Division-sharing	*One* share when *two* somethings are shared among (divided equally among) *five* people	two divided by five or $2 \div 5$ or $5\overline{)2}$
Ratio	The amount in one quantity compared to the amount in another quantity that is measured in the same way	the ratio two to five
Rate	The amount in one quantity for each amount in another quantity measured by a different unit	
	The measuring units for each quantity need to be given:	two *litres* of fuel per every five *kilometres*
	Sometimes the measuring unit is in fraction notation:	two and a half litres per kilometre $2\frac{1}{2}\ \frac{\text{litres}}{\text{kilometre}}$

Expressing fractions in words When a unit is divided into two equal parts, each part is called *one half*. Each of three equal parts of a unit is *one-third*. The names for other fractions are made by adding *th* to the number of parts



they are called *equivalent fractions*. The chart on the following page shows several equivalent fractions.

If you compare the part of the whole unit formed by $\frac{1}{2}$ with the part formed by two $\frac{1}{4}$'s, you can see that they have the same length. When $\frac{1}{2}$ of the original unit is broken into two equal parts, each of those new parts is $\frac{1}{4}$ of the whole unit. The chart also shows that three $\frac{1}{6}$'s are the same as $\frac{1}{2}$ broken into three equal parts, four $\frac{1}{8}$'s are $\frac{1}{2}$ broken into four equal parts, and so on.

Breaking each part of a fraction into more equal parts is the same as multiplying the numerator and the denominator of that fraction by the same number, which produces an equivalent fraction that has larger numbers in both the numerator and denominator.

To make an equivalent fraction with smaller numbers in both numerator and denominator, divide the numerator and denominator by the same number.

$$\frac{6 \div 2}{12 \div 2} = \frac{3}{6} \qquad \frac{5 \div 5}{10 \div 5} = \frac{1}{2}$$

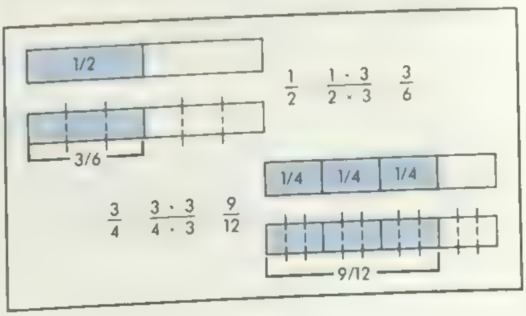
Finding an equivalent fraction with smaller numbers in the numerator and the denominator is called *reducing* the fraction. When no other number apart from 1 can be used to divide both the numerator and denominator evenly, the fraction is said to be *reduced to its lowest terms*.

Comparing fractions

When two fractions have the same denominator, it is easy to tell which fraction is larger. The fraction with the larger number in the numerator is larger, because more parts of the unit are being considered. For instance, $\frac{3}{5}$ of something is larger than $\frac{2}{5}$ of that same thing.

When two fractions have different denominators, it is more difficult to find out which fraction is larger. To compare fractions with different denominators, change the fractions into equivalent fractions. This process is called finding a *common denominator*. An easy way of finding a common denominator is to multiply the two original denominators and use that product as the com-

Multiplying to find equivalent fractions is like breaking a fractional part into smaller parts. For example, multiplying both the numerator and denominator of $\frac{1}{2}$ by 3 gives $\frac{3}{6}$, which expresses the same part of the whole as $\frac{1}{2}$. This operation is the same as breaking $\frac{1}{2}$ into three equal parts.

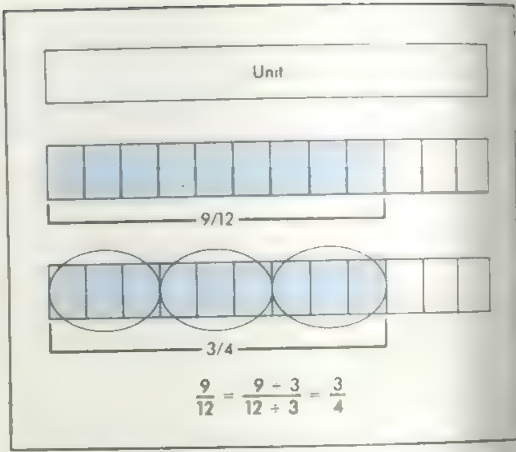


mon denominator. Then, multiply the numerator and denominator of each of the fractions by the number that will give the common denominator. For example, to find out which fraction is larger, $\frac{1}{2}$ or $\frac{3}{7}$, multiply the denominators to find the common denominator: $2 \times 7 = 14$. Fourteen will be the common denominator. To change $\frac{1}{2}$ to an equivalent fraction with 14 in the denominator, multiply both the numerator and the denominator by seven. To change $\frac{3}{7}$ to an equivalent fraction with a denominator of 14, multiply the numerator and the denominator by two, because $7 \times 2 = 14$.

$$\frac{3}{7} \times \frac{\ }{?} = \frac{\ }{14} \qquad 7 \times 2 = 14, \text{ so } \frac{3}{7} \times \frac{2}{2} = \frac{?}{14} = \frac{6}{14}$$

$$\frac{1}{2} \times \frac{\ }{?} = \frac{\ }{14} \qquad 2 \times 7 = 14, \text{ so } \frac{1}{2} \times \frac{7}{7} = \frac{?}{14} = \frac{7}{14}$$

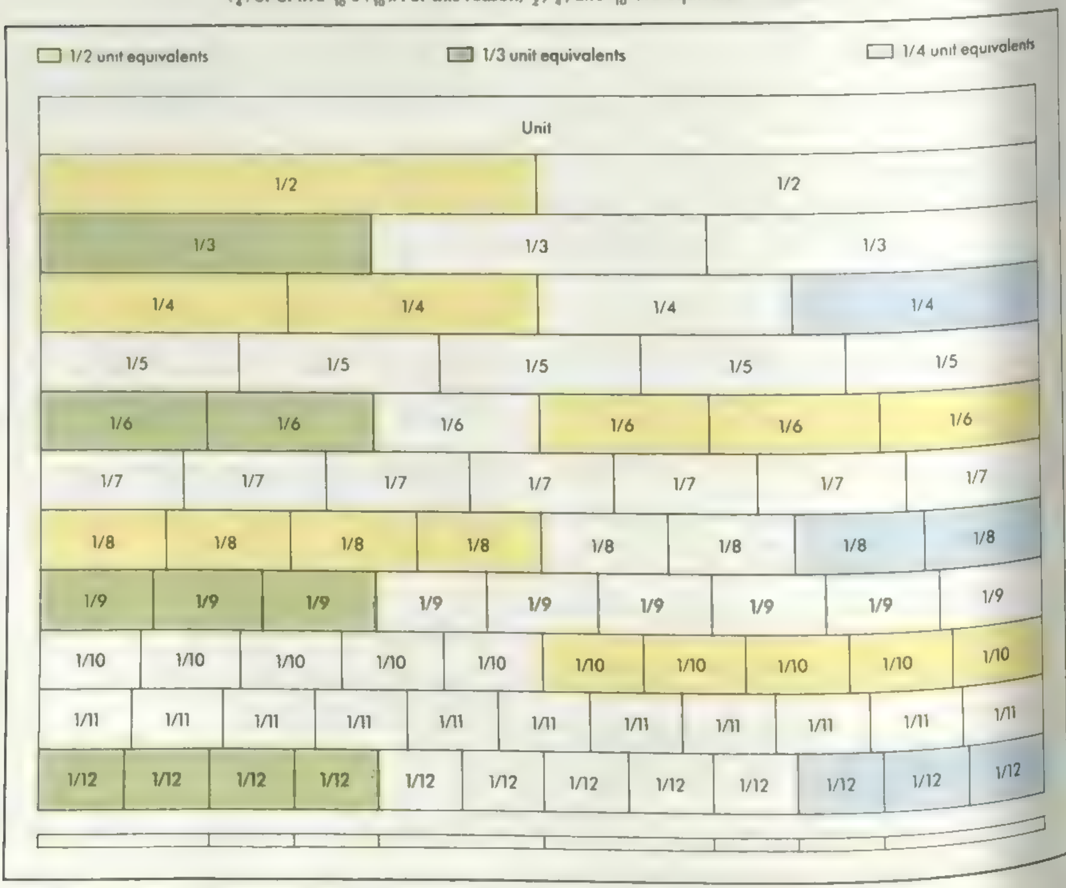
So, $\frac{3}{7}$ is equal to $\frac{6}{14}$ and $\frac{1}{2}$ is equal to $\frac{7}{14}$. Because $\frac{7}{14}$ is larger than $\frac{6}{14}$, $\frac{1}{2}$ is larger than $\frac{3}{7}$. This method of finding a common denominator may be thought of as multiplying both the numerator and the denominator of each fraction by the denominator of the other fraction.



Dividing to find equivalent fractions is called *reducing fractions*. For example, dividing the numerator and denominator of $\frac{9}{12}$ by 3 gives $\frac{3}{4}$. This is like grouping nine $\frac{1}{12}$'s into three groups of three $\frac{1}{12}$'s. Each group of three $\frac{1}{12}$'s equals $\frac{1}{4}$.

Equivalent fractions

Fractions may have different numerators and denominators and still express the same part of a whole unit. Such fractions are called *equivalent fractions*. The chart below shows a unit that has been divided into different fractional parts. It also shows several groups of fractional parts that are equivalent to $\frac{1}{2}$, $\frac{1}{3}$, or $\frac{1}{4}$. For example, $\frac{1}{2}$ expresses the same part of the unit as a group of two $\frac{1}{4}$'s ($\frac{2}{4}$) or of five $\frac{1}{10}$'s ($\frac{5}{10}$). For this reason, $\frac{1}{2}$, $\frac{2}{4}$, and $\frac{5}{10}$ are equivalent fractions.



Calculations using fractions

Addition and subtraction of fractions can be performed only when the fractions have the same denominator. When the denominators are the same, they name the same sized parts of the whole. You can add sevenths to sevenths to get sevenths. You can subtract thirds from thirds to get thirds. But you cannot add sevenths and thirds, or subtract thirds from seventh, without first making some extra calculations.

To add or subtract fractions that already have the same denominator, add or subtract the numerators, but do not change the denominator. The denominator in the answer will be the same as the denominator of the fractions in the problem. When fractions are added or subtracted, the total number of fractional parts changes, but the size of each of those parts does not change.

$$\frac{2}{6} + \frac{3}{6} = \frac{5}{6} \qquad \frac{7}{8} - \frac{5}{8} = \frac{2}{8}$$

To add or subtract fractions that have different denominators, first rename each fraction to an equivalent fraction so that the new fractions have a common denominator as in the following example. Then add or subtract.

$$\frac{2}{3} - \frac{1}{2} = \frac{2 \times 2}{3 \times 2} - \frac{1 \times 3}{2 \times 3} = \frac{4}{6} - \frac{3}{6} = \frac{1}{6}$$

Multiplication of fractions is similar to multiplication of whole numbers. One meaning for multiplication is that of repeated addition.

3×4 means $4 + 4 + 4$, or three groups of 4.

$3 \times \frac{1}{2}$ means $\frac{1}{2} + \frac{1}{2} + \frac{1}{2}$, or three groups of $\frac{1}{2}$, or three $\frac{1}{2}$'s.

When positive whole numbers are multiplied, the product is *larger* than either of the original numbers. But when a fraction is multiplied by a fraction, the product is *smaller* than the original fraction because you are just taking a part of it.

$\frac{2}{3} \times \frac{4}{5}$ means $\frac{2}{3}$ of $\frac{1}{5} + \frac{2}{3}$ of $\frac{1}{5} + \frac{2}{3}$ of $\frac{1}{5} + \frac{2}{3}$ of $\frac{1}{5}$, or $\frac{2}{3}$ of a group of four $\frac{1}{5}$'s, or $\frac{2}{3}$ of $\frac{4}{5}$.

The fraction $\frac{4}{5}$ stands for four of the parts formed when a unit is divided into five equal parts. The problem $\frac{2}{3} \times \frac{4}{5}$ means taking $\frac{2}{3}$ of each of those four $\frac{1}{5}$'s. We can find $\frac{2}{3}$ of $\frac{1}{5}$ by breaking $\frac{1}{5}$ into three equal parts and taking two of them. When a unit has been divided into five equal parts ($\frac{1}{5}$), and each of these five parts has been further divided into three equal parts ($\frac{1}{3}$), the result is that the original whole unit has been divided into 15 equal parts, or $\frac{1}{15}$'s. Therefore, $\frac{1}{3}$ of $\frac{1}{5}$ is $\frac{1}{15}$. If we take two $\frac{1}{15}$'s from each of four $\frac{1}{5}$'s, we have $\frac{2}{3}$ of $\frac{4}{5}$, or $\frac{8}{15}$.

To multiply two fractions, multiply their two numerators to get the new numerator. Then multiply their two denominators to get the new denominator.

$$\frac{1}{2} \times \frac{1}{4} = \frac{1 \times 1}{2 \times 4} = \frac{1}{8} \qquad \frac{5}{6} \times \frac{3}{4} = \frac{5 \times 3}{6 \times 4} = \frac{15}{24}$$

Another meaning of multiplication is that of area—length times width. A card that measures 3 centimetres wide and 5 centimetres long, or 3 *by* 5 (3×5) centimetres, has a total area of 15 square centimetres. The multiplication of fractions may also be thought of as the expression of area. For example, $\frac{2}{3} \times \frac{4}{5}$ may indicate the area of a rectangle that measures $\frac{2}{3}$ unit wide by $\frac{4}{5}$ unit long. The area formed by $\frac{2}{3}$ unit by $\frac{4}{5}$ unit includes eight of the 15 equal parts of the whole square unit. The rectangle therefore has an area that is $\frac{8}{15}$ of the area of the whole square unit. This answer is the same as that found by multiplying the numerators and multiplying the denominators of the two fractions.

Often, multiplication of fractions can be made easier by first performing *cancellation*. Cancellation involves dividing both a numerator and a denominator by the same number. This is the same as dividing a fraction by one, and so it does not alter the answer. When cancelling, cross out the old terms and write in the new terms. In the following problem, the 7's can be cancelled by dividing a numerator and a denominator by 7, and the 6 and the 8 can be cancelled by dividing by 2.

$$\frac{\overset{1}{\cancel{7}}}{\underset{4}{\cancel{8}}} \times \frac{\overset{3}{\cancel{6}}}{\underset{1}{\cancel{7}}} = \frac{3}{4}$$

Division. A division problem can be rewritten as a multiplication problem.

$63 \div 9$ means "how many 9's in 63?" or $9 \times ? = 63$.

$\frac{9}{20} \div \frac{3}{4}$ means "how many $\frac{3}{4}$'s in $\frac{9}{20}$?" or $\frac{3 \times ?}{4 \times ?} = \frac{9}{20}$.

The second problem can be rewritten as:

$$\frac{9 \div 3}{20 \div 4} = \frac{?}{?}$$

Comparing this problem with the original one, we see that to divide fractions we must divide the numerators to get the new numerator and divide the denominators to get the new denominator.

$$\frac{9}{20} \div \frac{3}{4} = \frac{9 \div 3}{20 \div 4} = \frac{3}{5}$$

However, many division problems do not come out even.

$$\frac{2}{5} \div \frac{3}{7} = \frac{2 \div 3}{5 \div 7}$$

Two cannot be divided evenly by three, and five cannot be divided evenly by seven. Using the division meaning of fractions, we can rewrite the original problem as a *complex fraction*. A complex fraction has a fraction in its numerator, in its denominator, or in both.

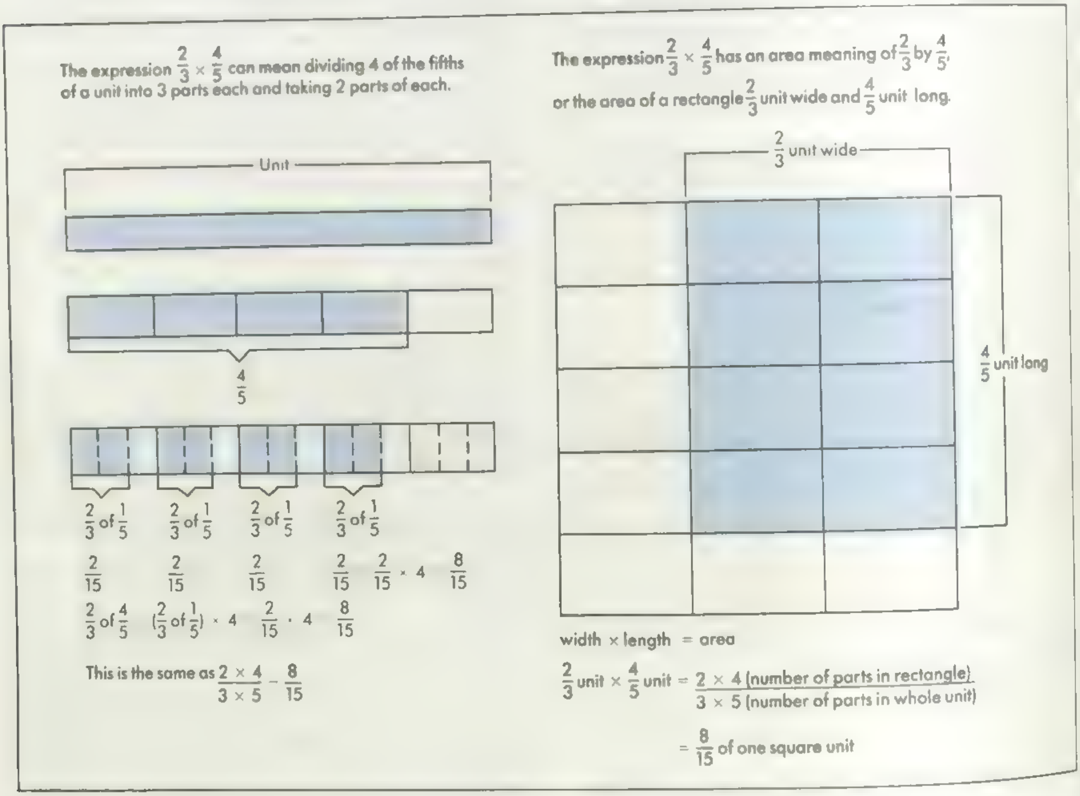
$$\frac{2}{5} \div \frac{3}{7} = \frac{\frac{2}{5}}{\frac{3}{7}}$$

We can simplify this problem by multiplying the fractions in the numerator and the denominator by the *inverse* of the denominator. The inverse of a fraction is formed by putting its numerator in the denominator and its denominator in the numerator. The inverse of $\frac{3}{7}$ is $\frac{7}{3}$. The product of any fraction and its inverse is one.

$$\frac{3}{7} \times \frac{7}{3} = \frac{3 \times 7}{7 \times 3} = \frac{21}{21} = 1$$

Two ways of multiplying fractions

The diagram on the left expresses the problem $\frac{2}{3} \times \frac{4}{5}$ by dividing a whole unit into smaller parts and then taking a fraction of those parts. The diagram on the right shows how multiplying fractions can be thought of in terms of area. The blue rectangle represents a fraction of the larger square. One side is $\frac{2}{3}$ of a side of the square, and the other is $\frac{4}{5}$ of a side of the square.



Multiplying both the numerator and the denominator of a complex fraction by the inverse of its denominator is the same as multiplying the complex fraction by one. This operation forms a simpler equivalent fraction with a denominator of 1.

$$\frac{2}{5} \div \frac{3}{7} = \frac{\frac{2}{5}}{\frac{3}{7}} = \frac{\frac{2}{5} \times \frac{7}{3}}{\frac{3}{7} \times \frac{7}{3}} = \frac{\frac{2}{5} \times \frac{7}{3}}{\frac{21}{21}} = \frac{\frac{2}{5} \times \frac{7}{3}}{1} = \frac{2}{5} \times \frac{7}{3}$$

So, $\frac{2}{5} \div \frac{3}{7} = \frac{2}{5} \times \frac{7}{3}$, or $\frac{2}{5}$ times the inverse of $\frac{3}{7}$. Dividing by a fraction is the same as multiplying by the inverse of that fraction.

$$\frac{2}{5} \div \frac{3}{7} = \frac{2}{5} \times \frac{7}{3} = \frac{2 \times 7}{5 \times 3} = \frac{14}{15}$$

Improper fractions

A fraction that has a numerator that is smaller than its denominator is called a *proper fraction*. A fraction in which the numerator is equal to or larger than the denominator is called an *improper fraction*. All improper fractions have a value that is equal to or greater than one. For example, the fraction $\frac{27}{20}$ stands for 27 of the parts formed when a unit is divided into 20 equal parts. Since one whole unit contains only 20 of 20 equal parts, $\frac{27}{20}$ must be larger than one unit. It is $\frac{7}{20}$ more than 1.

The value of the improper fraction $\frac{27}{20}$ may also be written as $1\frac{7}{20}$. Such a number, combining a whole number and a fraction, is called a *mixed number*. Thinking of the division meaning of fractions helps us understand how to change improper fractions to mixed numbers. For example, the improper fraction $\frac{26}{3}$ may be rewritten as 26 divided by 3.

$$\frac{26}{3} = 3\overline{)26} = 8\frac{2}{3} \qquad \begin{array}{r} 8 \\ 3\overline{)26} \\ \underline{24} \\ 2 \end{array}$$

To change a mixed number to an improper fraction, first write the mixed number as an addition problem. For example, the mixed number $5\frac{2}{3}$ has the same value as $5 + \frac{2}{3}$. The next step is to write the whole number as a fraction. Any whole number can be written in fraction form by using the whole number as the numerator and using 1 as the denominator. Therefore, 5 is written as $\frac{5}{1}$. After writing the whole number in fraction form, find a common denominator and add.

$$5\frac{2}{3} = \frac{5}{1} + \frac{2}{3} = \frac{5 \times 3}{1 \times 3} + \frac{2}{3} = \frac{15}{3} + \frac{2}{3} = \frac{17}{3}$$

A short cut is to multiply the whole number by the denominator of the fraction. Then add this product to the

numerator of the fraction and write the sum as the new numerator. The denominator remains the same.

$$6\frac{7}{8} = \frac{(6 \times 8) + 7}{8} = \frac{48 + 7}{8} = \frac{55}{8}$$

When adding or subtracting mixed numbers, you can write the mixed numbers as addition problems first. Then the whole numbers may be added or subtracted separately from the fractions.

$$9\frac{3}{8} + 4\frac{2}{5} =$$

$$9\frac{3}{8} = 9 + \frac{3}{8} = 9 + \frac{3 \times 5}{8 \times 5} = 9 + \frac{15}{40}$$

$$+\ 4\frac{2}{5} = 4 + \frac{2}{5} = 4 + \frac{2 \times 8}{5 \times 8} = 4 + \frac{16}{40}$$

$$13 + \frac{31}{40} = 13\frac{31}{40}$$

However, some problems that involve subtraction of mixed numbers are more complicated.

$$8\frac{1}{3} - 4\frac{2}{5} =$$

$$8\frac{1}{3} = 8 + \frac{1}{3} = 8 + \frac{1 \times 5}{3 \times 5} = 8 + \frac{5}{15}$$

$$-\ 4\frac{2}{5} = 4 + \frac{2}{5} = 4 + \frac{2 \times 3}{5 \times 3} = 4 + \frac{6}{15}$$

Normally, the next step would be to subtract the whole numbers and then subtract the fractions. But $\frac{6}{15}$ cannot be subtracted from $\frac{5}{15}$. To subtract these fractions, we must make the top fraction larger. This can be done by borrowing 1 from the 8. If we do so, the whole number becomes 7. Then, we can add the borrowed 1, in the form of $\frac{15}{15}$, to $\frac{5}{15}$ and subtract the fractions.

$$8 + \frac{5}{15} = 7 + 1 + \frac{5}{15} = 7 + \frac{15}{15} + \frac{5}{15} = 7 + \frac{20}{15}$$

$$-\ 4 + \frac{6}{15} = \qquad 4 + \frac{6}{15}$$

$$3 + \frac{14}{15} = 3\frac{14}{15}$$

To multiply or divide mixed numbers, change them to improper fractions. Then multiply or divide as usual.

History

More than 4,000 years ago, ancient Babylonian astronomers used fractions made by dividing a unit into 60 parts, then dividing each of these parts into 60 parts, and so on. This system is still used for telling time and for measuring angles in minutes and seconds. The ancient Chinese developed decimal fractions made by dividing units over and over again by 10.

Egyptian mathematicians who helped build the pyramids more than 4,000 years ago used only fractions with 1 in the numerator. Such fractions are called *unit fractions*. The use of only unit fractions made it necessary to express other fractional parts as sums. For example, $\frac{3}{4}$ is expressed in unit fractions as $\frac{1}{2} + \frac{1}{4}$.

About 2,000 years ago, the ancient Greeks wrote fractions with the numerator on the bottom and the denominator on the top. They did not separate the numerator and denominator by a line. Later, they began writing fractions with the numerator on the top and the denominator on the bottom. Hindu mathematicians in India adopted this method of writing fractions from the ancient Greeks.

During the A.D. 700's, Arabs conquered parts of India. There, the Arabs learned the decimal system and this method of writing fractions. During the 300 years that followed, the Arabs spread this knowledge through western Asia, across northern Africa, and into Spain.

During the late 1400's, several arithmetic books that explained the use of fractions and the decimal system were published in Europe. Following the publication of these books, large numbers of Europeans began to use fractions to perform everyday calculations.

Almost all countries other than the United States use the metric system of weights and measures. The metric system of measurement uses decimal fractions that are written with a decimal point rather than with a numerator and a denominator (see **Metric system**). In the United States, fractions are used mostly in connection with inches, cups, pounds, and other measurements in the former English system of measurement.

Many problems that were once done with fractions using paper and pencil are now done on electronic calculators. These calculators express fractions in the decimal form. As a result of these changes, there are fewer and fewer uses for the fraction form. However, the fraction form continues to be an important means of expressing rates, ratios, and division. The fraction form also continues to be important in algebra and in other special areas of mathematics as a method of writing rational numbers.

Related articles in *World Book* include:

Arithmetic
Decimal system
Percentage
Proportion
Ratio
Rational number

Outline

I. Expressing fractions
A. In words
B. In symbols
II. Equivalent fractions
III. Comparing fractions
IV. Calculations using fractions
A. Addition and subtraction
B. Multiplication
C. Division
V. Improper fractions
VI. History

Practice fraction examples

1. Sandy's house stands on a quarter-hectare plot. Her father bought the three-eighths hectare plot next to it. What is the size of the combined plots of land?

2. Mrs. Barry uses $\frac{3}{4}$ of a teaspoon of instant coffee to make one cup. How many teaspoons of instant coffee should she use to make six cups?

3. Lisa can "step off" distances. The average length of her step is $\frac{3}{4}$ metre. The length of her room measures 7 steps, and the width of her room measures 6 steps. How long is Lisa's room? How wide?

Answers to the practice examples

1. $\frac{5}{8}$ hectare
2. $4\frac{1}{2}$ teaspoons
3. $5\frac{1}{4}$ metres; $4\frac{1}{2}$ metres

Fractional distillation. See Distillation; Petroleum (Refining petroleum).

Fracture is a broken bone. There are many kinds of fractures. Common types include simple, compound, multiple, comminuted, greenstick, and spiral fractures. In a *simple fracture,* a bone breaks, but the skin over it does not. In a *compound fracture,* both the bone and skin break, and there is danger of infection. *Multiple fracture* means there is more than one break in a bone. *Comminuted fracture* means the bone has splintered, or shattered, usually owing to a crushing injury. In a *greenstick fracture,* the break occurs only part way through the bone. A *spiral fracture* results when a bone is broken by a twisting force.

People of all ages break bones. But the bones of old people are more fragile than those of young people. They break more easily and need more time to heal.

Doctors can detect a fracture in several ways. Usually, there is pain, soreness, or tenderness in a fracture area. Swelling and discoloration also occur. Sometimes, there is movement of the bone under the skin and obvious deformity. *Crepitus* often signals a broken bone. Crepitus is a harsh grating sound caused when the broken ends of the bone rub together. In some cases, only an X ray will reveal a fracture. Fractures require medical treatment. The injured part of the body should be immobilized until skilled help is available.

See also **First aid** (Fractures and dislocations).

Fragmentation is the breaking of any material into small pieces. The fragmentation bomb or shell has been used against troops, trucks, and grounded aircraft. This weapon has a heavy case that breaks into thousands of small *fragments* (pieces) when it explodes.

Bombs of this type are usually about 45 centimetres long and about 8 centimetres in diameter. They are made of a can of TNT (trinitrotoluene, a powerful explosive) with a heavy iron rod coiled around the can. Fragmentation shells fired from artillery guns have fuses that usually are set so the shells burst in the air.

See also **Bomb** (Fragmentation bombs).

Fragonard, Jean Honoré (1732-1806), was a French artist who painted in the delicate, decorative style known as rococo. Fragonard's favourite subjects were courtship and flirtation among the upper classes. He also became known for his portraits, especially of famous entertainers, and for his charming paintings of children. In addition, he was one of the leading landscape painters in French art. *The Swing* (1766), Fragonard's most famous painting, illustrates the rococo style at its peak. The painting appears in the **Painting** article.

Fragonard was born in Grasse, France. He studied with Jean Chardin and François Boucher, two noted French painters. Boucher, a leading rococo artist, strongly influenced Fragonard's style. Early in his career, Fragonard produced traditional paintings of historical subjects. He then began to paint the witty, romantic scenes that were typical of the rococo style. During the 1770's, Fragonard painted a series of pictures, called *The Progress of Love,* that are masterpieces of rococo art.

See also **Painting** (The 1600's and 1700's: Rococo); **Rococo.**

Framboesia. See Yaws.

Frame, Janet (1924-), a New Zealand writer, gained an international reputation as a novelist. Frame's books have great poetic sensitivity and show deep understanding of the minds of mentally disturbed people. She is best-known for her autobiographical trilogy *To the Is-Land* (1983), *An Angel at my Table* (1984), and *The Envoy from Mirror City* (1985). Her other novels include *Owls Do Cry* (1957), and *Faces in the Water* and *The Edge of the Alphabet,* both published in 1962. Janet Frame was born in Dunedin, New Zealand.

Frame construction. See **Building construction; House.**

Frampton, Sir George (1860-1928), was a British sculptor. Examples of his work in London are *Peter Pan* in Kensington Gardens, the lions at the British Museum, and the Edith Cavell Memorial near Trafalgar Square. His work can also be seen in Oxford, Winchester, and Glasgow. George James Frampton was born in London. He studied at the Royal Academy School and in Paris.

Franc is the standard coin of France. The franc is also used in Belgium, Luxembourg, Switzerland, and many other countries. For the franc's value in each country, see **Money** (table: Exchange rates).

Some common kinds of fractures


Simple


Compound


Multiple


Comminuted


Greenstick


Spiral

The French franc. On one side are the words "République Française" ("French Republic"), *left.* The other has the motto, "Liberté, Égalité, Fraternité" ("Liberty, Equality, Fraternity").

The Arc de Triomphe in Paris is a symbol of French patriotism. Napoleon Bonaparte began the stone arch as a monument to his troops in 1806, and King Louis Philippe completed it in 1836. Under the arch lies the tomb of France's Unknown Soldier of World War I.

France

France is the largest country of Western Europe in area. Paris, the capital of France and largest city in the country, ranks as one of the world's great cities. For hundreds of years, Paris has been a world capital of art and learning. Its university is over 800 years old, and is one of the largest in the world. Paris attracts artists and writers of all nationalities. Many great artists have produced their finest masterpieces there. It is a city renowned for its beauty and magnificent architecture. Every year, millions of tourists visit such famous Paris landmarks as the Cathedral of Notre Dame, the Eiffel Tower, and the Louvre—which is one of the largest art museums in the world.

There is much more to France than just Paris, however. The snow-capped Alps form the border between France and Italy and attract many climbers and skiers every year. Sunny beaches and steep cliffs stretch along the French coast on the Mediterranean Sea. The French Riviera, the stretch of coast by the Italian border, is a popular holiday region. Fishing villages dot the Atlantic coast of northwestern France.

The peaceful, wooded Loire Valley has many historic *châteaux* (castles). Colourful apple orchards, dairy farms, and vineyards are located throughout much of the countryside. Many regions of France have fields of golden wheat.

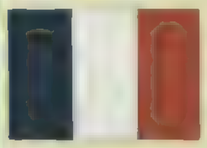
France in brief

General information

Capital: Paris
Official language: French
Official name: Republique Française (French Republic)
National anthem: "La Marseillaise."
National motto: *Liberté, Egalite, Fraternité* (Liberty, Equality, Fraternity)

Largest population centres (1982 census)

Cities	Metropolitan areas
Paris (2,176,243)	Paris (8,706,963)
Marseille (874,436)	Lyon (1,236,096)
Lyon (413,095)	Marseille (1,115,697)
Toulouse (347,995)	Lille (945,572)
Nice (337,085)	Bordeaux (650,123)



The French flag is called the Tricolour. In 1789, King Louis XVI first used its three colours to represent France. France has no official coat of arms.

Land and climate

Land: France lies in western Europe, with coastlines on the Atlantic Ocean and Mediterranean Sea. The country borders Spain, Italy, Switzerland, Germany, Belgium, and Luxembourg, and lies across the English Channel from the United Kingdom. The Pyrenees Mountains separate France from Spain. The Alps border Italy; the Alps and Jura Mountains border Switzerland. The Central Highlands occupies south-central France. Most of northern, western, and north-central France is flat or has rolling hills. Major rivers include the Loire, Seine, and Rhône.

Area: 543,965 km², including mainland France and Corsica. *Greatest distances*—east-west, 974 km; north-south, 950 km. *Coastline*— 3,701 km.
Elevation: *Highest*—Mont Blanc, 4,807 m. *Lowest*—below sea level at the Rhône River delta.
Climate: Warm summers and cool winters, except on the Mediterranean coast, which is warmer in all seasons. Typical daytime summer high about 24 °C in the north; 28 °C on the Mediterranean coast. Winter daytime highs about 6 °C in the north; about 12 °C on the Mediterranean coast. Moderate precipitation all year round, except for dry summers along the Mediterranean.

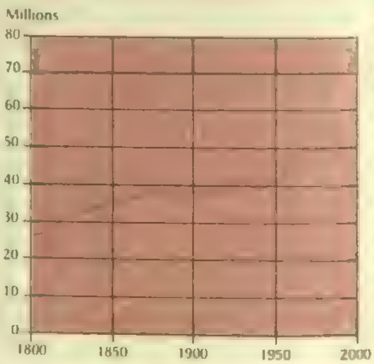
Government

Form of government: Parliamentary democracy
Head of state: President (elected by people to 7-year term)
Head of government: Prime minister.
Legislature: Parliament of two houses—the National Assembly (577 members) and the Senate (319 members). The National Assembly is more powerful than the Senate
Executive: Prime minister and president each have some executive powers.
Judiciary: Highest court is the Court of Cassation.
Political subdivisions: 22 regions, containing 96 metropolitan departments.

People

Population: *1996 estimate*—57,971,000; *1990 census* 56,556,000. *2001 estimate*—58,939,000
Population density: 104 people per km²
Distribution: 74 per cent urban, 26 per cent rural
Major ethnic/national groups: About 93 per cent French (including Basques, Bretons, and others who have long lived in France). About 7 per cent recent immigrants and their descendants—mostly from Algeria, Morocco, Tunisia, Italy, Portugal, Spain, Turkey, and Indochina.
Major religions: 75 per cent Roman Catholic, 3 per cent Muslim, 2 per cent Protestant, 1 per cent Jewish.

Population trend



Year	
1801	27,349,000
1821	30,462,000
1831	32,569,000
1841	34,230,000
1851	35,783,000
1861	37,386,000
1871	36,103,000
1881	37,406,000
1891	38,133,000
1901	38,451,000
1911	39,192,000
1921	38,798,000
1931	41,228,000
1946	39,848,000
1954	42,781,000
1962	46,500,000
1975	52,544,000
1982	54,335,000

Economy

Chief products: *Agriculture*—beef cattle, milk, wheat, grapes, sugar beet, potatoes, apples, pigs, chickens and eggs. *Manufacturing*—iron and steel, chemicals, cars, electronic goods, textiles and clothing, aerospace equipment, processed foods and beverages, railway equipment. *Mining*—iron ore.
Money: *Currency unit*—French franc. One franc = 100 centimes.
Gross national product: *1987 total GNP*—$714,994,000,000. *1987 GNP per capita*—$12,860.
Foreign trade: *Major exported goods*—chemicals, machinery, electrical and electronic equipment, cars, aircraft, weapons, wine, grain, iron and steel. *Value of exported goods and services*—$219,645,000,000 (1987). *Major imported goods*—petroleum, machinery, chemicals. *Value of imported goods and services*—$223,722,000,000 (1987). *Main trading partners*—Germany, Italy, Belgium, United Kingdom, United States, Netherlands, Spain.

Highlights

Paris. Cultural, industrial, and commercial centre of France. One of the world's most beautiful cities. For highlights, see **Paris** (Paris in brief).

Northwestern France

Normandy. Named after the Norsemen who first raided and settled there in the 800's and early 900's. Area of beautiful fields and orchards; coast alternates between sandy beaches and rocky cliffs.

Le Havre. Second only to Marseille among French seaports.

Rouen. Cathedral built between the 1200's and 1500's, includes several phases of Gothic architecture.

Mont-Saint-Michel. Abbey on tiny island connected by causeway to coast.

Bayeux. Museum houses the Bayeux Tapestry, a medieval work of embroidery about 70 metres long that depicts the story of the Norman conquest of Britain in 1066.

D-Day beaches. On Normandy coast invaded by Allies during World War II (June 1944).

Channel crossings. Shortest ferry crossing is from Calais, France to Dover, England. Tunnel linking the two countries built during the 1980's and 1990's.

West Central France

Brittany. Picturesque rocky shore with many fishing villages. Many people still speak Breton, a language related to Welsh. Bretons originated in Britain, went to Brittany in the 400's to 600's, fleeing from Angles and Saxons invading England.

Carnac (near Vannes). Mysterious, prehistoric stone monuments and tombs.

Nantes. Shipping and industrial centre. Edict of Nantes, signed by King Henry IV in 1598, gave limited religious freedom to Huguenots (French Protestants).

Loire River valley. Châteaux (country mansions built for kings and nobles), including Chambord (near Blois) and Chenonceau and Azay-le-Rideau (both near Tours).

Chartres. Early Gothic cathedral built in the 1100's and early 1200's.

Orléans. Joan of Arc saved the city from the invading English in 1429.

Le Mans. Annual 24-hour car race.

Southwestern France

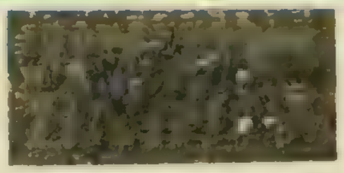
Basque country. The coast from Bayonne southward and in the western Pyrenees. Sheepherders and fishing people. Jai alai, a traditional Basque sport, played in the area. Beach resort of Biarritz.

Lourdes. Lourdes receives several million visitors each year.

Dordogne River valley. Pleasant mix of fields, forests, and picturesque towns. Popular for tourist rambles.

Prehistoric cave paintings. Animals drawn by Cro-Magnon people more than 10,000 years ago: Lascaux (closed to public to protect paintings), Les Eyzies (some still open).

Toulouse. University city and aerospace centre.



Beaujolais vineyard

Bordeaux. Seaport, commercial centre. Many vineyards nearby.

Cognac. Source of cognac brandy.

Limoges. Porcelain-manufacturing.

Poitiers. Romanesque churches dating back to the 1000's and 1100's.

South Central France

Auvergne. Massif Central, a rugged area of extinct volcanoes.

Cévennes Mountains. Craggy peaks, caves, gorges, canoeing and kayaking. Cévennes National Park.

Clermont-Ferrand. Industrial centre; makes car tyres.

Carcassonne. Huge, many-towered fortress, more than 2,000 years old.

Montpellier. Ancient but bustling university town.

Perpignan. Town near Spanish border, architecture has Spanish flavour.

Southeastern France

Provence. Colonized by Greeks about 600 B.C. Ruins of Roman amphitheatre and baths at Arles; Roman aqueduct and temples at Nîmes. Provençal, a dialect of French, major language used in European literature during the Middle Ages.

Avignon. Home of the popes, 1309 to 1377. Papal palace.

Marseille. France's chief seaport and oldest city.

French Riviera. The coastline for about 150 kilometres westward from the Italian border. Sunshine, mild temperatures, and the combination of sea and nearby mountains attract tourists. *Corniches* (twisting, cliffside roads). Mountaintop villages; *calanques* (fiordlike inlets); azure sea; sandy beaches only in a few places. Resort towns include Antibes, Cannes, Menton, Nice, St. Tropez.

Nice. Medium-sized city and commercial centre. Castle Hill, a wooded outcrop with floodlit waterfall, offers panoramic views of city and sea. Colourful Russian Orthodox church built in 1900's.

Monte Carlo. Gambling casino in independent country of Monaco.

Carcassonne

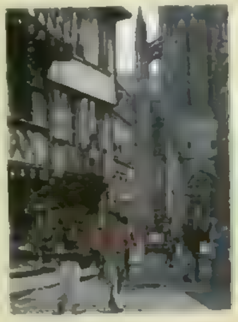
Camargue. Marshy area in delta of Rhône River. Zoological and botanical preserve. Flamingos, water birds, horses.

East Central France

Lyon. Industrial, commercial, and educational centre. Chemicals, machinery, textiles. Excellent regional food.

Burgundy. Independent country for centuries, dotted with vineyards and mustard fields. Dijon, chief city of Burgundy, has many examples of medieval architecture.

French Alps. Snowcapped peaks, blue lakes, rushing rivers. Vanoise National Park.



Brittany *(left)*
Corsica harbour *(right)*

Chamonix. Ski resort near Mont Blanc. Cable car to Aiguille du Midi is the world's highest; it travels over the mountain into Italy. Cog train to Mer de Glace glacier.

Grenoble. University town, scientific research, engineering industries; alpine sports centre.

Jura Mountains. On the Swiss border north of Lake Geneva.

Northeastern France

Alsace-Lorraine. Long contested between France and Germany, strongly French in allegiance, cultural atmosphere combines French and German.

Strasbourg. Headquarters of Council of Europe. Gothic cathedral with famous clock and rose window.

Metz. Manufacturing centre in Lorraine.

Nancy. Place Stanislaus (a public square decorated in the 1700's by Stanislaus, a deposed king of Poland).

North Central France

Fontainebleau: Favourite palace of Napoleon, set in a former royal hunting forest 56 kilometres southeast of Paris.

Champagne and Picardy. Battlegrounds in many European wars. Limestone caves used as wine cellars for champagne. Cathedrals at Amiens, Laon, Reims.

Lille. City is part of chief industrial centre in northern France.

Corsica. Island in the Mediterranean, 160 kilometres southeast of the mainland. Rugged scenery of mountains and coast. Birthplace of Napoleon.

Fashion styles from Paris are copied by clothing manufacturers throughout the world. This model wears an evening ensemble by French designer Jean-Louis Scherrer at a fashion show.

The French countryside has many picturesque villages. This village lies in the Perigord region of southwestern France. Many French villagers farm the land or work in nearby cities.

Open-air markets spill out onto the pavements of many French cities and towns. These shoppers are selecting fresh fruits and vegetables. The French value good food and skilful cooking.

The French are famous for their enjoyment of life. Good food and good wine are an important part of everyday living for most French people. The wines of France are considered to be the best in the world. Almost every restaurant and area has at least one special recipe of its own. The delicious breads, appetizers, sauces, soups, and desserts of France are imitated by cooks in most parts of the world.

France has a long and colourful history. Julius Caesar and his Roman soldiers conquered the region before the time of Christ. Then, after Rome fell, the Franks and other Germanic tribes invaded the region. France was named after the Franks. By the A.D. 800's, the mighty Charlemagne, king of the Franks, had built the area into a huge kingdom.

In 1792, during the French Revolution, France became one of the first nations to overthrow its king and set up a republic. A few years later, Napoleon Bonaparte seized power. He conquered much of Europe before he finally was defeated. During World Wars I and II, France became a bloody battleground for Allied armies and the invading German forces.

France is not only a beautiful and historic country, it is also rich and powerful. France has great car, chemical, and steel industries. It is a leader in growing wheat, vegetables, and many other crops. France stands fifth among the countries of the world in its trade with other nations, as measured by exports. France also plays an important part in world politics. Its foreign policies affect millions of people in other countries.

The political importance of France today has resulted partly from the leadership of Charles de Gaulle, who served as president of the country from 1958 to 1969. De Gaulle established a strong French republic. He looked on France as a world power and followed a policy that was independent of both the United States and the Communist nations. De Gaulle ended France's close military ties with the United States and tried to improve relations with Communist countries. De Gaulle's actions angered many other nations, but to the proud people of France he was a symbol of their nation's greatness.

Government

France is a parliamentary democracy with a strong national government. Its present government, called the *Fifth Republic,* has been in effect since 1958. The First Republic was established in 1792. Between 1792 and 1958, the structure of the French government changed many times.

France's national government has three branches. They are (1) an executive branch headed by a president and a prime minister, (2) a legislative branch consisting of a Parliament, and (3) a judicial branch, or system of courts. The French constitution provides each branch of government with certain powers, but the branches' functions sometimes overlap.

National government. The president of France is elected to a seven-year term by voters aged 18 or older. The president can serve an unlimited number of terms. The president appoints the prime minister (also called premier). The prime minister chooses the other ministers who make up the *Council of Ministers* (cabinet). The president is considered the *head of state* and the prime minister is *head of the government.* The president manages the nation's foreign affairs. The prime minister directs the day-to-day operations of the government.

France's Parliament consists of two houses, the National Assembly and the Senate. The National Assembly consists of 577 *deputies,* elected by the voters for five-year terms, unless an election is called earlier. The president has the power to dissolve the National Assembly and call for new elections. The Senate has 319 members. Senators are elected to nine-year terms by regional and city electoral colleges. The National Assembly is more powerful than the Senate. For example, if the two houses disagree on the text of a proposed law, the National Assembly makes the final decision. In addition, the Council of Ministers must have the support of a majority of members in the National Assembly. Without such a majority, the ministers must resign and the president appoint a new prime minister.

Local government. The basic unit of local government in France is the *commune.* France has about 36,500 communes, which range in size from small villages to large cities. Each commune is governed by a mayor and a local council.

Mainland France and the island of Corsica are divided into 96 *metropolitan departments.* Each department is administered by a locally elected council. Each also has a commissioner (formerly a prefect), who is appointed by the national government and who represents the government. Each department is part of one of France's 22 regions. Each region has a regional council, elected by the people, and a president elected by the council members. The region of Corsica has a special status with more local independence.

France has nine inhabited overseas possessions: Guadeloupe and Martinique, both in the West Indies; Reunion and Mayotte, both in the Indian Ocean; New Caledonia, French Polynesia, and the Wallis and Futuna Islands, all in the South Pacific Ocean; French Guiana in South America; and Saint-Pierre and Miquelon in the North Atlantic Ocean. These possessions are considered to be part of France. Their people vote for the president of France and send representatives to both houses of the French Parliament.

Politics. France has several political parties. The Socialist Party and the French Communist Party hold liberal or radical views. In theory, both parties support public ownership or control of most of the country's factories, machines, and other basic means of production. In practice, however, the Socialists have cooperated with private business since the 1930's. Both the Socialists and the Communists support strong, government financed social security and medical benefits. The chief conservative political parties in France are the Union for French Democracy (UDF) and the Rally for the Republic (RPR). The UDF has called for removing government regulations that restrict individuals and companies from operating freely in the French economy. The RPR supports the policies of former French President Charles de Gaulle. It favours a strong national government and an aggressive foreign policy. The National Front, an extreme conservative political party, opposes immigration and favours the death penalty.

Courts are in the major cities of each department. Appeals from civil and criminal courts may be taken to *Courts of Appeal.* The *Courts of Assizes* hear cases involving murder and other serious crimes. The decisions of the Courts of Appeal and Assizes are generally final. But the *Court of Cassation,* the highest court of France, may review them. It can return cases to the lower courts for new trials. A minister of justice controls appointments and promotions of judges. Judges are appointed for life.

Armed forces. Men aged 18 to 35 must serve one year of active duty in the French armed forces. About 550,000 men and women serve in the army, navy, and air force. The French government spends about 20 per cent of its national budget on the military.

People

Among the people of France, there are notable regional differences in language and traditions. As a result, many people in France have a strong sense of regional identity. In the regions of Corsica and Brittany, some people have organized to work for independence from France. However, most people in the various regions of France feel comfortable having both a regional identity and a national "French" identity.

Population. France has a population of about 56 million. About a sixth of the French people live in the Paris metropolitan area, one of the largest metropolitan areas in the world. France has 36 cities with populations of over 100,000. Five of the cities have more than 300,000 people. In order of size, they are Paris, Marseille, Lyon, Toulouse, and Nice. See the articles on French cities listed in the *Related articles* at the end of this article.

France map index

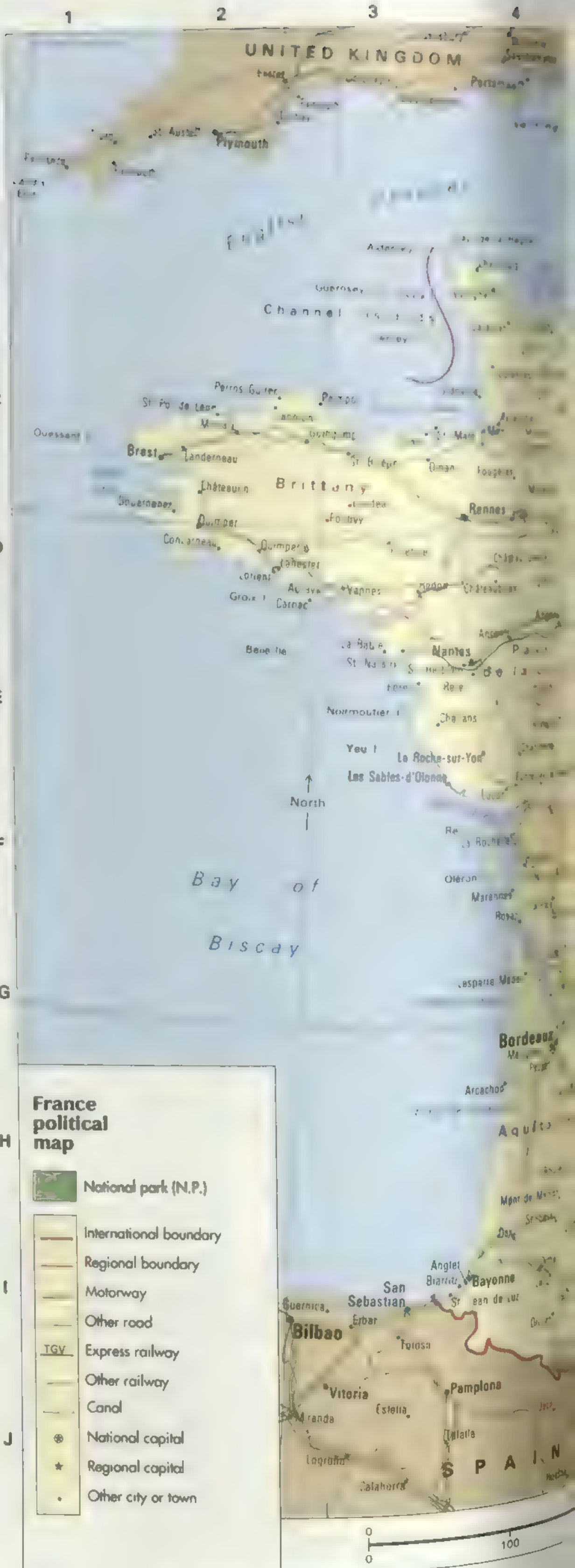
Cities and towns

Abbeville	[illegible]	B	[illegible]
Agen	[illegible]	H	[illegible]
Aix-en-Provence	[illegible]		
	[illegible]		9
Aix-les-Bains	[illegible]		9
Ajaccio	[illegible]		
Albertville	[illegible]		9
Albi	[illegible]		[illegible]
Alençon	[illegible]		5
Alès	[illegible]		8
Alfortville*	[illegible]		
Amiens	[illegible]		
	[illegible]	B	6
Angers	[illegible]		
	[illegible]		4
Anglet	[illegible]		[illegible]
Angoulême	[illegible]		
	[illegible]		5
Annecy	[illegible]		
	[illegible]		9
Annemasse	[illegible]		9
Annonay	[illegible]		8
Antibes	[illegible]		
Antony*	[illegible]		6
Argenteuil*	[illegible]		6
Arles	[illegible]		8
Armentières	[illegible]	A	
Arras	[illegible]		
	[illegible]	A	
Asnières*	[illegible]		6
Aubagne	[illegible]		9
Aubervilliers*	[illegible]		
Auch	[illegible]		5
Audincourt	[illegible]	D	10
Aulnay*	[illegible]		
Aurillac	[illegible]		
Autun	[illegible]		8
Auxerre	[illegible]	D	
Avignon	[illegible]		
	[illegible]	H	9
Azay-le-Rideau*	[illegible]		5
Bagneux*	[illegible]		6
Bar-le-Duc	[illegible]		8
Bastia	[illegible]	I	11
Bayonne	[illegible]		
	[illegible]	I	4
Beauvais	[illegible]	B	6
Belfort	[illegible]	D	10
Bergerac	[illegible]	H	5
Besançon	[illegible]		
	[illegible]	E	9
Béthune	[illegible]		
	†259 [illegible]	A	[illegible]
Béziers	[illegible]	I	[illegible]
Biarritz	[illegible]	I	[illegible]
Blois	[illegible]	D	6
Bobigny*	[illegible]	C	6
Bondy*	[illegible]	C	7
Bordeaux	[illegible]		
	†685 456	G	4
Boulogne-Billancourt	[illegible]	C	6
Boulogne-sur-Mer	44 244		
	†95 930	A	6
Bourg-en-Bresse	42 955	F	8
Bourges	[illegible]		
	†92 720	E	7
Bourg-la-Reine	[illegible]	C	6
Brest	[illegible]		
	[illegible]	C	1
Brétigny*	[illegible]	C	6
Brive	[illegible]	G	6
Bron*	40 514	F	8
Bruay-en-Artois	†22 893	A	6
Caen	115 624		
	†188 799	C	5
Cagnes	[illegible]	I	10
Cahors	20 787	H	6
Calais	75 836		
	†101 768	A	6
Caluire-et-Cuire*	41 513	F	8
Cambrai	34 210	B	7
Cannes	69 363		
	†335 647	I	10
Carcassonne	44 991	I	7
Carpentras	25 477	H	9
Castres	46 292	I	6
Cavaillon	23 470	I	9
Chalon	56 259	E	8
Châlons-sur-Marne	51,533	C	8
Chambéry	55 603		
	†102 548	G	9
Chamonix	10 062	F	10
Champigny*	79 778	C	7
Charenton*	21 991	C	6
Charleville-Mézières	59,439	B	8
Chartres	41 850	D	6
Châteauroux	52 949	E	6
Châtellerault	35,691	E	5
Chaumont	28 900	D	8
Chelles*	45 495	C	7
Chenôve	17 865	E	8
Cherbourg	28 773		
	†92,045	B	4
Cholet	56 540	E	4
Clamart*	47,755	C	6
Clermont-Ferrand	140,167		
	†254 416	G	7

Clichy*	[illegible]	C	6
Cognac	[illegible]	G	4
Colmar	[illegible]		
	[illegible]	D	10
Colombes*	[illegible]	C	6
Colomiers	[illegible]	I	6
Compiègne	[illegible]	B	7
Concarneau	[illegible]	D	2
Conflans*	[illegible]	C	6
Corbeil-Essonnes	[illegible]		6
Courbevoie*	[illegible]		6
Creil	[illegible]		
	[illegible]		6
Créteil	[illegible]		7
Cro[illegible]	[illegible]		6
Dax	[illegible]		4
Denain	[illegible]	A	7
Dieppe	[illegible]	B	5
Dijon	[illegible]		
	[illegible]	E	9
Dole	[illegible]	E	9
Douai	[illegible]		
	[illegible]	A	7
Douarnenez	[illegible]	D	2
Draguignan	[illegible]	I	10
Drancy*	[illegible]	C	6
Draveil*	[illegible]	C	6
Dreux*	[illegible]	C	6
Dunkerque	[illegible]		
	[illegible]	A	6
Échirolles*	[illegible]	G	9
Elbeuf	[illegible]	C	5
Épernay	[illegible]	C	7
Épinal	[illegible]	D	9
Épinay*	[illegible]	C	6
Ermont*	[illegible]	C	6
Étampes	[illegible]	D	6
Évreux	[illegible]	C	6
Évry	[illegible]	C	6
Fécamp	[illegible]	B	5
Firminy	[illegible]	G	8
Flers	[illegible]	C	4
Fontaine	[illegible]	G	9
Fontainebleau	[illegible]	D	7
Fontenay-aux-Roses*	23 534	C	6
Fontenay-sous-Bois*	52 105	C	6
Forbach	[illegible]		
	†97 847	C	9
Fougères	23 138	D	4
Franconville*	33 874	C	6
Fréjus	42 613	I	10
Fresnes*	27 032	C	6
Gagny*	36 151	C	7
Gap	35 647	H	9
Garges-lès-Gonesse*	42 236	C	6
Gennevilliers*	45 052	C	6
Givors	19 833	G	8
Grasse	42 077	I	10
Grenoble	153 973		
	†400 141	G	9
Grigny*	24 969	C	6
Haguenau	30 384	C	10
Hautmont	17 556	B	8
Hazebrouck	21 115	A	6
Hénin-Beaumont*	26 494	B	7
Houilles*	30 027	C	6
Hyères	50 122	I	10
Issy*	46 734	C	6
Istres	36 516	I	8
Ivry*	54 106	C	6
Joué	37 144	E	5
La Ciotat	30 748	I	9
La Courneuve*	34 351	C	6
Lambersart*	28 462	A	7
Lanester	23 163	D	2
Laon	28 670	B	7
La Rochelle	73 744		
	†100 264	F	4
La Roche-sur-Yon	48 518	E	3
La Seyne	60 567	I	9
Laval	53 479	D	4
Le Blanc-Mesnil*	47 093	C	6
Le Cannet	42 005	I	10
Le Chesnay*	29 613	C	6
Le Creusot	29 230	E	8
Le Grand-Quevilly*	27 909	C	6
Le Havre	197 219		
	†253 627	B	5
Le Mans	148 465		
	†189 107	D	5
Lens	35 278		
	†323 174	A	7
Le Perreux*	28 540	C	7
Le Plessis-Robinson*	21 349	C	6
Le Puy	23,434	G	8
Les Mureaux*	33 365	C	6
Levallois-Perret*	47 788	C	6
L'Haÿ-les-Roses*	29 841	C	6
Libourne	21 931	G	5
Liévin	34 012	A	7
Lille	178 301		
	†950 265	A	7
Limoges	136 407		
	†170 065	F	6
Lisieux	24 506	C	5
Livry-Gargan*	35,471	C	7
Longwy	15,647	B	9

See footnotes at end of index.

(Index continued on page 398.)




5
6
7
8
9
10
11
A
B
C
D
E
F
G
H
I
J
Brussels
BELGIUM
Cologne
Lille
Frankfurt
GERMANY
LUXEMBOURG
Amiens
Reims
Paris
Stuttgart
Le Mans
Orleans
Chambord
Centre
Tours
Dijon
Besançon
Bourges
Valençay
FRANCE
SWITZERLAND
Châteauroux
Poitiers
Argenton sur Creuse
Montluçon
Guéret
Aubusson
Limoges
Limousin
Clermont Ferrand
Lyon
Auvergne
St. Etienne
Grenoble
ITALY
Turin
Mauriac
Brive
Les Eyzies
Bergerac
Rocamadour
Figeac
Cahors
Espalion
Decazeville
Rodez
Millau
Villefranche
Agen
Moissac
Montauban
Carmaux
Albi
Lacaune
Castres
Lodève
Languedoc
Roussillon
Montpellier
Avignon
Nimes
Aix en Provence
Marseille
Toulon
Aubagne
Nice
MONACO
Cannes
Midi Pyrénées
Toulouse
Auch
Mirande
Mazamet
Castelnaudary
Carcassonne
Pamiers
Limoux
St Gaudens
St Girons
Foix
Ax les Thermes
Prades
Perpignan
Céret
ANDORRA
Seo de Urgel
Ripoll
Olot
Figueras
Cape Creus
Mediterranean Sea
Narbonne
Agde
Sète
Bagneres de Bigorre
Tarbes
Bastia
Corsica
Sartène
Bonifacio
Same scale as main map
200
300
400 Miles
200
300
400
500
600 Kilometres

Lons-le-Saunier	[illegible]	I	9
Lorient	[illegible]		
	†[illegible]	D	[illegible]
Lourdes	16,581	I	5
Lunéville	22,393	C	9
Lyon	422,444		
	†1,262,223	F	8
Mâcon	38,508	F	8
Maisons-Alfort*	54,065	C	6
Malakoff*	31,135	C	6
Mantes-la-Jolie	45,254		
	†188,103	C	6
Marcq-en-Baroeul*	36,898	A	[illegible]
Marignane*	32,542	I	9
Marseille	807,726		
	†1,087,372	I	9
Martigues	42,922	I	9
Massy*	38,972	C	6
Maubeuge	35,225		
	†102,772	A	8
Meaux	49,409	C	[illegible]
Melun	36,489		
	†92,459	C	[illegible]
Menton	29,474	I	11
Mérignac	58,684	G	4
Metz	123,920		
	†193,117	C	9
Meudon*	46,173	C	6
Meyzieu*	28,212	G	9
Millau	22,458	H	[illegible]
Montargis	[illegible]	D	[illegible]
Montauban	[illegible]	H	6
Montbéliard	[illegible]		
	†117,510	D	10
Montceau-les-Mines	23,308	E	8
Mont-de-Marsan	31,864	J	4
Montélimar	31,386	H	8
Montereau	18,936	D	7
Montigny	23,482	C	9
Montluçon	46,660	F	7
Montpellier	210,866		
	†236,788	J	8
Montreuil*	95,038	C	7
Montrouge*	38,333	C	6
Morlaix	17,607	C	2
Moulins	23,353	F	7
Mulhouse	108,905		
	†223,856	D	10
Nancy	102,410		
	†[illegible]	C	9
Nanterre*	86,627	C	6
Nantes	252,029		
	†492,255	E	3
Narbonne	47,086	J	7
Neuilly-sur-Marne*	31,603	C	7
Neuilly-sur-Seine*	62,033	C	6
Nevers	43,889	E	7
Nice	345,674		
	†475,507	J	10
Nîmes	133,607		
	†138,527	J	8
Niort	58,660	F	4
Noisy-le-Grand*	54,112	C	7
Noisy-le-Sec*	36,402	C	7
Orange	28,136	H	8
Orléans	107,965		
	†243,153	D	6
Orly*	21,824	C	6
Orsay*	14,931	C	6
Oullins*	26,400	F	8
Oyonnax	23,992	F	9
Palaiseau*	29,398	C	6
Pantin*	47,444	C	6
Paris	2,175,200		
	†9,060,257	C	6
Pau	83,928		
	†134,625	I	5
Périgueux	32,848	G	5
Perpignan	108,049		
	†138,735	J	7
Pessac	51,424	H	4
Poissy	36,864	C	6
Poitiers	82,507		
	†105,268	F	5
Pontoise	28,463	C	6
Puteaux*	42,917	C	6
Quimper	62,541	D	2
Reims	185,164		
	†206,362	C	8
Rennes	203,533		
	†245,065	D	4
Rezé	33,703	E	4
Rillieux*	31,149	G	8
Roanne	42,848		
	†77,160	F	8
Rochefort	26,949	F	4
Rodez	26,794	H	7
Romans	33,546	G	9
Rosny-sous-Bois*	37,779	C	7
Roubaix	98,179	A	7
Rouen	105,470		
	†380,161	B	5
Royan	17,500	G	4
Rueil-Malmaison*	67,323	C	6
St.-Brieuc	47,370		
	†83,661	C	3
St.-Chamond	39,262		
	†81,795	G	8
St.-Cloud*	28,673	C	6
St.-Denis	90,806	C	6
St.-Dié	23,670	D	10
St.-Dizier	35,558	C	8
St.-Étienne	201,564		
	†313,338	G	8
St.-Étienne-du-Rouvray	31,012	C	6
St.-Germain-en-Laye*	41,710	C	6
St.-Herblain	43,439	E	3
St.-Lô	22,819	C	4
St.-Malo	49,274	C	3
St.-Martin-d'Hères*	34,501	G	9
St.-Maur*	77,492	C	6
St.-Nazaire	66,087		
	†[illegible]	E	3
St.-Ouen*	42,611	C	6
St.-Pol-sur-Mer	24,013	A	6
St.-Priest*	42,131	G	8
St.-Quentin	62,085	B	7
St.-Raphaël	26,799	I	10
Ste.-Geneviève-des-Bois*	[illegible]	D	6
Saintes	27,546	G	4
Salon	35,041	J	9
Sarcelles*	57,121	C	6
Sarreguemines	23,684	C	10
Sartrouville*	50,443	C	6
Saumur	31,894	E	5
Savigny*	[illegible]	C	6
Schiltigheim	[illegible]	C	10
Sedan	22,407	B	8
Sens	27,755	D	7
Sète	41,916	I	8
Sevran*	48,564	C	7
Sèvres*	22,057	C	6
Six-Fours	29,178	I	9
Soissons	32,144	C	7
Sotteville	29,957	B	6
Stains*	35,068	C	6
Strasbourg	255,937		
	†388,483	C	10
Suresnes*	36,950	C	6
Talence*	36,172	H	4
Tarbes	50,228	I	5
Thiais*	27,933	C	6
Thionville	40,835		
	†132,413	B	9
Thonon	30,667	F	10
Toulon	170,167		
	†437,553	I	9
Toulouse	365,933		
	†608,430	I	6
Tourcoing	94,425	A	7
Tours	133,403		
	†271,927	E	5
Trappes*	30,938	C	6
Tremblay-lès-Gonesse*	31,432	C	7
Troyes	60,755		
	†122,763	D	8
Tulle	18,685	G	6
Valence	65,026		
	†107,965	G	9
Valenciennes	39,276		
	†336,481	A	7
Vandoeuvre-lès-Nancy	34,420	C	9
Vannes	48,454	D	3
Vanves	26,160	C	6
Vaulx-en-Velin*	44,535	F	8
Vénissieux	60,744	G	8
Verdun	23,427	C	8
Vernon	24,943	C	6
Versailles	91,029	C	6
Vesoul	19,404	D	9
Vichy	28,048	F	7
Vienne	30,386	G	8
Vierzon	32,900	E	6
Vigneux-sur-Seine*	25,265	C	6
Villefranche	29,889	F	8
Villejuif*	48,671	C	6
Villemomble*	27,000	C	6
Villenave-d'Ornon*	25,957	H	4
Villeneuve-d'Ascq*	65,695	A	7
Villeneuve-la-Garenne*	23,872	C	6
Villeneuve-le-Roi*	20,378	C	6
Villeneuve-St.-Georges*	27,476	C	6
Villeneuve-sur-Lot	23,760	H	5
Villeurbanne	119,848	F	8
Villiers-le-Bel*	26,223	C	6
Vincennes*	42,651	C	6
Viry-Châtillon*	30,738	C	6
Vitry-le-François	17,483	C	8
Vitry-sur-Seine*	82,820	C	6
Voiron	19,221	G	9
Wattrelos*	43,784	A	7
Yerres*	27,268	C	6

*Does not appear on map; key shows general location.
†Population of metropolitan area, including suburbs.
‡1982 census.
Source: 1990 census.

Population density

The population distribution of mainland France is fairly even. Paris is the most heavily populated urban area. On Corsica, pictured in the bottom right-hand corner of the map, most people live near the coast.

About 7 per cent of France's population consists of foreign residents. The largest foreign groups are people from Algeria, Morocco, Tunisia, Italy, Portugal, Spain, Turkey, and Indochina. In recent years, hundreds of thousands of refugees from former French colonies in Africa and Indochina have moved to France. The status of these immigrants is a controversial issue in the country. For example, Algerian immigrants represent a large work force that the country has not yet absorbed. Algerian workers are often the first to be laid off during periods of slow economic activity. Because they send most of their earnings home, many of them live in poor neighbourhoods. Some immigrants from Morocco, Portugal, Tunisia, and Turkey are in similar situations. On the other hand, many Vietnamese refugees have become more fully integrated into French society.

Ancestry. In ancient times, peoples known as *Gauls* lived in what is now France (see **Gaul**). The Gauls were a Celtic people related to the Welsh and the Irish. Roman, Germanic, and then Norse invaders came from the south, east, and north. The Romans brought peace to the warring Gallic tribes, and Roman law became the basis of modern French law. The name of France came from Germanic conquerors called *Franks.* Many people of northeastern France have Germanic ancestors. Some people from Normandy trace their ancestry back to the Norse people who settled there.

Language. By about the 1500's, the language that is now called French was spoken only in the area around

Paris. The rest of the people living in what is now France spoke Basque, Breton, Dutch, or German, or dialects related to modern French, such as Walloon, Picard, or Provençal. The building of the modern French nation is closely tied to the standardization and increased use of the local dialect of Paris, beginning in the 1500's. For a detailed discussion of the French language, including its development, see **French language.**

On the island of Corsica, the majority of the population speak a dialect similar to Italian. A group of people living along the Pyrenees Mountains speak Basque. The region of Brittany has a significant number of people who speak Breton. Along the border with Belgium, many people speak the Flemish dialect of Dutch. The region of Alsace has many German-speaking people. In all of these regions, however, French is taught in the schools and the number of people who speak the regional tongue has dwindled from one generation to the next. In Corsica, Brittany, and the Pyrenees, people have formed groups to promote the use of the local language.

Villages set amid well-tended fields typify much of rural France. About a quarter of the French live in rural areas. Most enjoy the same modern comforts as city dwellers.

Way of life

City life. Almost three-quarters of the French people live in cities and towns of at least 2,000 people. The Paris metropolitan area has about 9 million people. In the larger cities, most people live in apartments. Many Parisians live in old apartment buildings. In general, the older a building is, the more prestigious it is. Many French city dwellers tolerate buildings with old plumbing and appliances so that they may enjoy antique fireplaces and other features of the architecture.

Strict zoning regulations help protect and enhance the centre of many French cities. Such regulations may prohibit traffic on certain city streets or limit high-rise construction in the centre of a city. The regulations are designed to ensure a high quality of life for urban residents. Such urban problems as overcrowding and high crime rates are more likely to occur in the outskirts of cities or in nearby suburbs.

Apartment buildings, such as these in Lyon, are home to many French city dwellers.

While city living is generally pleasant, it is also expensive. Many poor city residents live outside the city centres in run-down apartments or in housing complexes built by the government. Many middle-class people cannot afford to live in Paris, and instead live in a suburb as a second choice. Public transport systems carry people from the suburbs to a variety of jobs and recreational and cultural activities in the city.

Rural life. Only about a quarter of the French people live in rural areas. However, France traditionally has been an agricultural society. The French people are thus more familiar with—and more respectful of—such rural activities as farming and hunting than are people in many urbanized countries.

Most rural residents enjoy the same comforts and conveniences as city dwellers. Most of them live in single-family houses in villages or on farms. They often own cars and television sets and have such modern appliances as refrigerators and washing machines.

Farmers and their families make up much of the rural population of France. Most farmers own their land. Some rent all or part of their land. A few French farmers are wealthy. But many farmers require other sources of income to support their families. A spouse or another family member may hold a job as a factory worker, office worker, or teacher. In poorer areas such as Brittany, some farmers earn barely enough to support themselves.

One problem for rural France is that most of its farms are too small to compete with the farms of many other western European countries. For this reason, French farms cannot support all those born and raised on them. Since 1959, the rural population of France has dropped by almost half.

Food and drink. The French consider cooking an art. French *haute cuisine* (gourmet cooking) has set a stand-

ard accepted in many parts of the world since the 1700's. French chefs have created many delicious sauces and appetizers. French appetizers include *escargots* (snails) in garlic butter sauce, scallops and mushrooms in a creamy wine sauce, and puff pastries filled with chicken in cream sauce. Sausages and *pâtés* (chopped meat cooked with spices) also serve as appetizers. Goose liver pâté with black mushroomlike *truffles* is considered a special delicacy. French cooks sometimes put tasty fillings of cheese, vegetables, shrimp, ham, or bacon into omelettes, *crêpes* (thin, rolled pancakes), and *quiches* (custard baked in a pastry shell). These dishes can be served as appetizers or as light meals.

A typical French main meal has several courses. It starts with an appetizer or onion or potato soup. Popular main courses include steaks, chops, and roast chicken, served with French fried potatoes. A green salad often follows the main course, then cheese or fresh fruit. Crusty French bread accompanies most courses. A very special meal might add a light fish course before the main course and a dessert after the cheese course. Desserts include fancy pastries, fruit tarts, and crêpes filled with whipped cream or cooked fruit.

Such hearty French specialities as *bouillabaisse* and *cassoulet* make a full meal and need few extras. Bouillabaisse is a chunky fish soup with six or more kinds of fish and shellfish. Cassoulet is a casserole of beans, sausage, poultry, and pork.

The French eat light breakfasts. A typical breakfast consists of such soft rolls as *croissants* and *brioches,* served with butter and jam, plus coffee.

Some French people drink wine at lunch and dinner, sometimes different wines with different courses. Beer, cider, or mineral water may substitute for wine. Coffee is served at breakfast, and after other meals.

Recreation. The greatest national sporting event in France is the Tour de France, a bicycle race. Every summer, more than a hundred professional cyclists race around almost the entire country. They ride daily for nearly a month, and finish in Paris. Thousands of spectators line the route and cheer them along.

France's most popular team sport is football. Almost every area and region in France has its own football team. The French also enjoy such sports as *boules* (a form of bowls), fishing, ice skating, rugby, skiing, swimming, and tennis.

All French workers are entitled to receive five weeks' paid holiday every year. In July and August, cars filled with holiday-makers crowd the main roads leading south to the mountains and the Mediterranean Sea. To accommodate holiday-makers, there are thousands of special camps and inexpensive resorts that organize activities for children and adults. Many French people have second homes in the country. Holiday festivals in many southern cities feature music, theatre, parades, and folk dancing.

Throughout the year, many city dwellers take daily walks through public parks. They may stop at one of the pavement cafes that dot many city boulevards. Many French people also enjoy watching television and listening to the radio. Television programmes made in the United States have become especially popular.

Holidays. Most French holidays and festivals are closely connected with the Roman Catholic Church. Many cities celebrate Shrove Tuesday, the last day before Lent, with a merry festival called *Carnaval.* The Carnaval celebration in Nice includes a colourful parade, and attracts many tourists. Most villages honour their local patron saints with a festival in July.

At *Noël* (Christmas), French families hold reunions and the children receive gifts (see **Christmas** [In France]). The people also exchange gifts on *Le Jour de l'An* (New Year's Day). At *Pâques* (Easter), the children receive coloured sugar eggs and chocolate chickens.

The Tour de France is the greatest national sporting event in France. Each summer, more than 100 of the world's top cyclists compete in the nearly month-long race.

Pavement cafes provide a pleasant place for French people to stop to eat or drink and meet with friends. The cafes are popular spots in most French cities and towns.

The French national holiday is Bastille Day, July 14. It marks the capture of the Bastille, a fortified prison, by the people of Paris in 1789, during the French Revolution. A large military parade is held in Paris on Bastille Day. At night, the people watch fireworks and sometimes dance in the streets until dawn. The French also celebrate Labour Day on May 1, and Armistice Day on November 11.

Religion. About 75 per cent of the French people are Roman Catholics. About 3 per cent are Muslims, and about 2 per cent are Protestants. About 1 per cent are Jews. France has more Jews than any other European country. From 1801 to 1905, the French government recognized Roman Catholicism as the religion of the majority of the people. Bishops and priests were state officials, and were paid by the government. This church-state connection, established by Napoleon and Pope Pius VII, was broken by French law in 1905.

Education. French children between the ages of 6 and 16 must go to school. About 85 per cent of children attend state schools. The others attend private schools, most of which are run by the Roman Catholic Church.

Children from the ages of 2 to 6 may attend free nursery schools. Reading is taught during the last year of these schools. Children from the ages of 6 to 11 attend primary schools. Formerly, boys and girls went to separate schools. But since the 1970's, they have attended school together. After five years of primary school, children enter a *collège.* A collège is a four-year school.

After collège, students enter either a vocational secondary school or a general secondary school. Both kinds of secondary schools are called *lycées.* Vocational secondary schools offer job training in business, crafts, farming, and industry. General secondary schools provide a three-year course that prepares students to enter university. The last year of such schools is a period of specialized study in one of five areas. These areas are

Bastille Day, July 14, is France's national holiday. The people of France celebrate the holiday with parades, fireworks, and dancing. These dancers are performing at a celebration in Arles.

French museums are among the best in the world. The Orsay Museum, *above,* occupies a restored former railway station in Paris. It displays art from the 1800's and 1900's.

philosophy, experimental sciences, mathematics, mathematics and technology, and economics and social sciences. A *baccalauréat* examination completes this programme. This examination is so difficult that about a third of the students fail to pass it.

France has about 75 universities. Each university selects its own courses and teaching methods. Students have a voice in university administration. The government provides financial support for students.

France also has schools of higher education called *Grandes Écoles* (Great Schools). They prepare students for high-ranking careers in the civil and military services, commerce, education, industry, and other fields.

Museums and libraries. France has many excellent museums. The best known, the Louvre in Paris, is one of the largest art museums in the world (see **Louvre**). Many old castles and palaces are national historical museums. They include the palace at Versailles, built by King Louis XIV (see **Versailles**). The Orsay Museum in Paris, located in a beautifully restored former railway station, exhibits paintings from the 1800's and 1900's—including many impressionist works. The Georges Pompidou National Centre of Art and Culture in Paris includes a museum of modern art, a major public reference library, and a museum of industrial design. The Museum of Man has important scientific exhibits.

There are public libraries in all large French cities. France's national library, the Bibliothèque Nationale in Paris, is one of the largest libraries in Western Europe (see **Bibliothèque Nationale**). Other important libraries include the Mazarine Library of the Institute of France, the country's major learned society. The University of Paris also has fine libraries.

Arts

Since the Middle Ages, French artists, composers, architects, and writers have been among the cultural leaders of Europe. During many periods of history, French styles in painting, music, drama, and other art forms served as models for other Western countries. This section discusses the major art movements in France. For more information, see **French literature, Architecture, Sculpture, Painting,** and **Classical music** with their lists of *Related articles.*

The Middle Ages. The greatest works of medieval French art were magnificent Gothic cathedrals built from about 1150 to 1300. The finest examples include the Cathedral of Notre Dame in Paris and cathedrals in the cities of Amiens, Chartres, Reims, and Rouen. Much of the finest French sculpture of the time was created as decoration for the Gothic cathedrals.

Poetry was the most important literary form among medieval French writers. Musician-poets called *troubadors* wrote love songs in the Provençal dialect of southern France. Poets called *trouvères* carried this poetry to northern France. Other medieval poets wrote epic poems and long fictional works called *romances.*

The Renaissance was an important cultural period that reached its height during the 1400's and 1500's. François Rabelais was the most important French fiction writer of the French Renaissance. His satirical *Gargantua and Pantagruel* (1532-1564) is a masterpiece of Western literature. Seven French poets called the Pléiade wanted to create a new kind of French poetry based on ancient Greek and Roman models. Pierre de Ronsard and Joachim du Bellay were the group's major poets. Michel de Montaigne was the last great writer of this period. He created the personal essay as a literary form.

The finest French Renaissance architecture appeared as magnificent castles called *châteaux.* The best examples include those at Fontainebleau, Chambord, and Azay-le-Rideau. All were built in the early 1500's.

Baroque and rococo art developed in France during the 1600's and 1700's. Baroque art was large in scale and dramatic. Perhaps the greatest monument to baroque art in France is the spectacular palace at Versailles (begun about 1661).

The major French baroque composers were Jean Baptiste Lully and Jean Philippe Rameau, both known for their operas. François Couperin was an important composer of music for a keyboard instrument called the *harpsichord.*

Rococo art was smaller in scale and more delicate than that of the baroque style. The leading rococo artists were three painters—François Boucher, Jean Honoré Fragonard, and Antoine Watteau.

French classical art spanned the 1600's and 1700's as well. It stressed order, balance, and harmony, and placed heavy emphasis on the role of the intellect in analysing human behaviour. François de Malherbe was the first and greatest classical poet. His clear, rational, and sober poems became the basic style for classical verse. In prose, the leaders were two philosophers, René Descartes and Blaise Pascal.

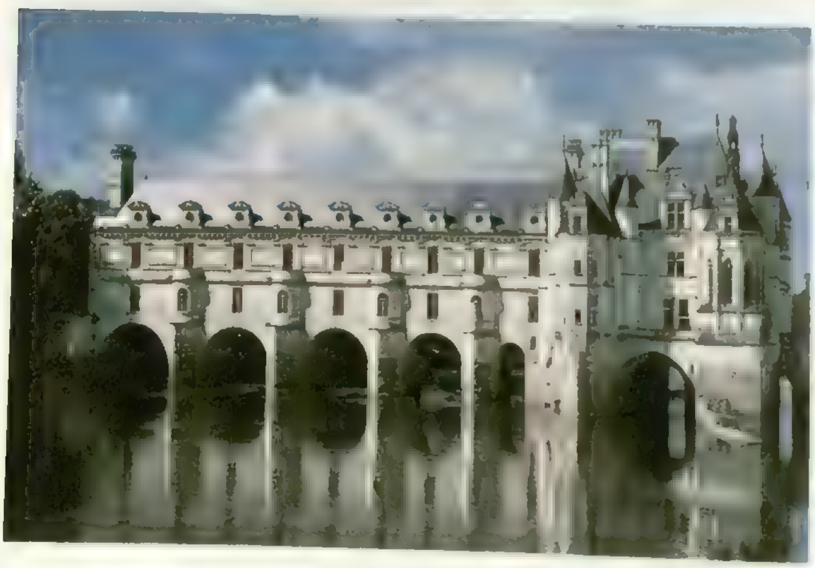
The greatest expression of French classical literature was in drama. The major figures were Pierre Corneille, Jean Racine, and Molière. Corneille and Racine wrote tragedies. Molière ranks as the greatest writer of comedy in French drama.

In painting, classical ideals were best represented by Claude. His landscapes illustrate the classical admiration for balance, harmony, and order.

The Age of Reason, also called the *Enlightenment,* was a period of intellectual achievement in the 1600's and 1700's dominated by philosophical literature. Writers of this period emphasized reason and observation as the best methods of learning truth. The crucial figures in this movement were Voltaire, Jean Jacques Rousseau, and Denis Diderot.

Romanticism began in the late 1700's and flourished until the mid-1800's. It was partly a reaction against the attitudes of classicism and the Age of Reason. For example, romantic art and literature stressed emotions and the imagination rather than self-discipline and reason.

Jean Jacques Rousseau was a major personality in ro-



Castles called *châteaux* were the high point of French Renaissance architecture. Many of these magnificent castles stand in the Loire Valley. At Chenonceaux, near Tours, a château spans the River Cher, *left.* It was built in the 1500's.

Monument to Balzac (189?), a bronze statue; Museum of Modern Art, New York City

Sculptor Auguste Rodin created many expressive figures. One of his finest works is a statue of French author Honore de Balzac.

manticism even though he was also a leader of the Enlightenment. The greatest romantic writer was the novelist, poet, and playwright Victor Hugo. Honoré de Balzac, Stendhal, and George Sand were also outstanding romantic novelists, though their work was more realistic than that of the typical romantic novelist.

Romantic painting was colourful and dramatic. It is best represented in the painting of Théodore Géricault and Eugène Delacroix. Auguste Rodin is recognized as the greatest romantic sculptor, though he worked later in the 1800's than most other romantic artists.

Hector Berlioz was the greatest French romantic composer. He gained fame for his large-scale orchestral works. Georges Bizet wrote the romantic *Carmen* (1875), probably the most popular opera ever written.

Realism and naturalism were movements of the middle and late 1800's that tried to portray life accurately and objectively. Gustave Flaubert was the major representative of realism, notably for his novel *Madame Bovary* (1857). Guy de Maupassant gained recognition for his realistic short stories. Naturalism, an extreme form of realism, was led by novelist Emile Zola.

Impressionism was a movement of the late 1800's and early 1900's centred on French painting. The impressionists tried to capture the immediate impression of an object or event. The leading impressionist painters included Edouard Manet, Camille Pissarro, Edgar Degas, Claude Monet, and Pierre Renoir. A movement called *postimpressionism* developed out of impressionism. The key French postimpressionists were Paul Cézanne, Paul Gauguin, Georges Seurat, and Henri de Toulouse-Lautrec. The movement produced two great composers, Claude Debussy and Maurice Ravel.

The 1900's. Paul Claudel, Andre Gide, Marcel Proust, and Paul Valery were the leading French writers of the early 1900's. Claudel wrote works that reflect his deep Roman Catholic faith. Gide and Proust were major novelists. Valery wrote classical poetry.

St. John on Patmos, a manuscript painting from *The Hours of Etienne Chevalier* (1450-1455), Musée Conde, Chantilly, France

The Table (1925), an oil painting on canvas; Tate Gallery London

French painting has produced great works for centuries. In the 1400's, Jean Fouquet painted richly coloured miniatures, *left*. The work of artists such as Pierre Bonnard, *right*, made France the centre of Western painting in the late 1800's and early 1900's.

Detail of a room (late 1600's) in the palace of Versailles, France

Masterpieces of French decorative art include beautiful tapestries and carpets, and richly carved furniture.

Philosophers Jean-Paul Sartre and Albert Camus wrote important drama and essays in the mid-1900's. Major French writers of the late 1900's include Alain Robbe-Grillet, Claude Simon, and Marguerite Duras.

Such painters as Georges Braque, Pablo Picasso (who was born in Spain), Georges Rouault, and Fernand Leger helped shape modern art. Sculptors Aristide Maillol, Jean Arp, and Antoine Pevsner were also important. The Swiss-born French architect Le Corbusier had a great influence on architecture with his *International Style*.

Composers Pierre Boulez and Olivier Messiaen were leaders in experimental music. Boulez became known for his work in electronic music.

The land

France has wide differences in geography. The northern and western regions consist mainly of flat or rolling plains. Hills and mountains rise in the eastern, central, and southern parts of France. France is divided into 10 main land regions. They are (1) the Brittany-Normandy Hills, (2) the Northern France Plains, (3) the Northeastern Plateaus, (4) the Rhine Valley, (5) the Aquitanian Lowlands, (6) the Central Highlands, (7) the French Alps and Jura Mountains, (8) the Pyrenees Mountains, (9) the Mediterranean Lowlands and Rhône-Saône Valley, and (10) Corsica.

The Brittany-Normandy Hills have low, rounded hills and rolling plains. This region consists of ancient rock covered by poor soils, with some fertile areas along the coast. Apple orchards, dairy farms, and grasslands crisscross the land. In some areas, thick hedges separate the fields. Many bays indent the rugged coast and have important fishing harbours.

The Northern France Plains have highly fertile soils and productive industries. The plains are flat or rolling, and are broken up by forest-covered hills and plateaus. This heavily populated region includes Paris. The Paris Basin, also called the Île-de-France, is a large, circular area drained by the Seine and other major rivers. East of Paris, a series of rocky ridges resembles the upturned edge of a huge saucer. Coal is mined near the Belgian border.

The Northeastern Plateaus share the Ardennes Mountains with Belgium. This wooded region becomes a little more rugged to the southeast, in the Vosges Mountains. It has great deposits of iron ore, and produces iron and steel. Farmers rear livestock and grow a variety of crops on the lower slopes and in the valleys. Foresters operate in the area.

The Rhine Valley has steep slopes and a flat valley floor. Trees and vines cover the slopes, and rich farmland lies along the Rhine River. This river, which forms part of France's boundary with Germany, is the main inland waterway in Europe. Important roads and railways follow its course.

The Aquitanian Lowlands are drained by the Garonne River and the streams that flow into it. Sandy beaches lie along the coast. Inland, the region has pine forests, rolling plains, and sand dunes. Its many vineyards supply grapes for France's important wine industry. Oil and natural gas fields are located near Landes, a forested area about 100 kilometres south of the major port of Bordeaux.

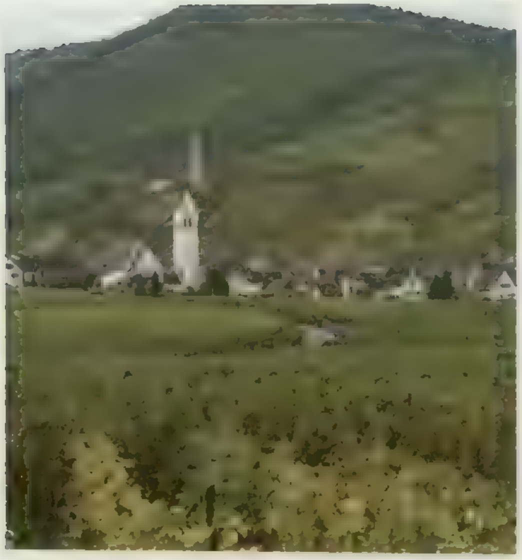
The Central Highlands, or *Massif Central,* is thinly populated. The soils in the region are poor, except in some valleys, where rye and other crops are grown. Cattle and sheep graze on the lower grasslands, and forests cover the higher slopes. The Loire River, about 1,050 kilometres long, rises in the Cévennes Mountains. The Loire is the longest river in France. See **Loire River**.

The French Alps and Jura Mountains border on Italy and Switzerland. Snow-capped Mont Blanc, the highest point in France, rises 4,807 metres. Many tourists visit nearby Chamonix and other ski resorts in the mountains.

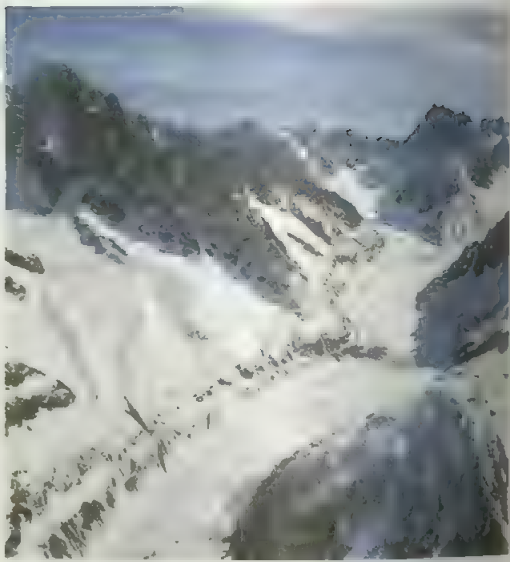
The cliffs of Normandy rise along the English Channel, in the Brittany-Normandy Hills of northwestern France. Most of this region consists of ancient rock covered by poor soils. However, there are some fertile areas near the coast.

Physical features

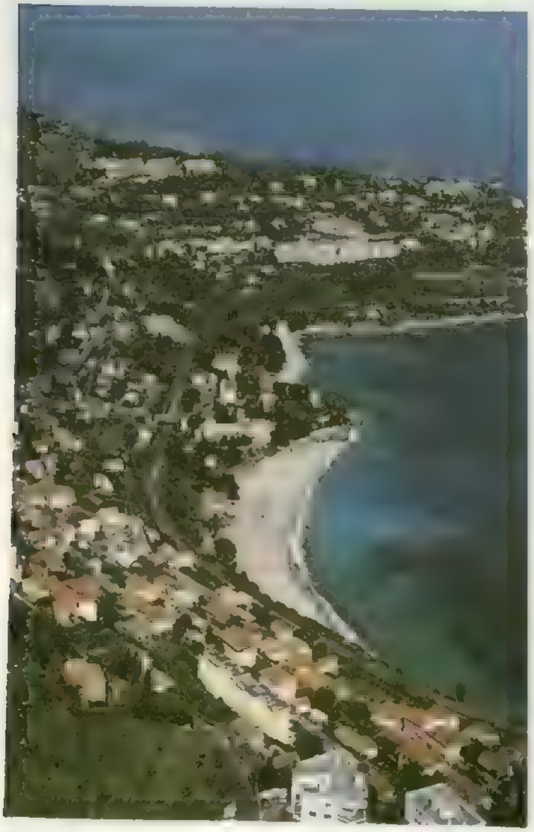
Adour River	F	3
Aisne River	B	5
Allier River	E	5
Alps (mountains)	E	7
Ardennes Mountains	B	6
Argonne Plateau	B	6
Bassin d Arcachon (inlet)	E	2
Bay of Biscay	E	1
Bay of the Seine	B	3
Belfort Gap (pass)	C	7
Belle Île (island)	C	1
Brittany Hills	C	2
Canal du Midi	F	4
Cap de la Hague (cape)	B	2
Cap Gris-Nez (cape)	A	4
Cévennes (mountains)	E	5
Cher River	D	4
Côte d Or (hills)	C	6
Cotentin (peninsula)	B	2
Côtes de Meuse (hills)	B	6
Creuse River	D	4
Dordogne River	E	4
Doubs River	C	6
Durance River	F	6
English Channel	A	2
Étang de Berre (lagoon)	F	6
Eure River	B	4
Garonne River	E	3
Gave de Pau (stream)	F	3
Gironde (estuary)	E	3
Gulf of Lion	F	5
Gulf of St Malo	B	2
Hyères Islands	F	[illegible]
Isère River	F	6
Jura Mountains	D	6
Lake Grand Lieu	D	2
Limousin Plateau	E	4
Loir River	C	4
Loire River	C	5
Lorraine Plateau	B	6
Lot River	E	4
Maritime Alps (mountains)	E	7
Marne River	B	5
Massif Central (mountains)	E	5
Mediterranean Sea	G	6
Meuse River	B	6
Mont Blanc (mountain)	D	7
Mont Cenis Pass	E	7
Mont Cinto (mountain)	G	[illegible]
Mont Pelat (mountain)	E	[illegible]
Moselle River	B	6
Nivernais Hills	C	5
Noirmoutier Island	D	2
Normandy Hills	B	3
Oise River	B	5
Oléron Island	D	2
Ouessant Island	B	1
Paris Basin	B	4
Pertuis Breton (strait)	D	2
Pic de Vignemale (mountain)	F	3
Puy de Sancy (mountain)	E	5
Pyrenees Mountains	F	4
Ré Island	D	2
Rhine River	C	[illegible]
Rhône Delta	F	6
Rhône River	E	6
Riviera (coast)	F	7
Saône River	D	6
Sarthe River	C	3
Seine River	B	4
Somme River	A	4
Strait of Dover	A	4
Tarn River	F	4
Vienne River	D	4
Vilaine River	C	2
Vosges (mountains)	C	7
Yonne River	C	5



In Alsace, on the Northeastern Plateaus, vineyards spread over the rolling valleys and lower slopes of the Vosges Mountains. The region also has large forests and many potash deposits.



Mont Blanc, in the French Alps, is the highest peak in France, rising 4,807 metres. A thick blanket of snow always covers most of the top half of the mountain.



The sunny Riviera is warmed by breezes from the Mediterranean Sea. The Alps shield the area from cold north winds. The Riviera's ideal climate attracts holiday-makers all year round.

Mountain streams provide much hydroelectric power. See **Alps.**

The Pyrenees Mountains extend along France's border with Spain. Many peaks in this range rise more than 3,000 metres. The rugged mountains have poor soils and are thinly populated. See **Pyrenees.**

The Mediterranean Lowlands and Rhône-Saône Valley region has productive farming areas, and irrigation is used widely. Fruit, vegetables, and grapes for wine are important products. Marseille, on the Mediterranean Sea, is the leading seaport of France. The coast also includes the Riviera, a famous resort area. See **Rhône River; Riviera.**

Corsica is a Mediterranean island about 160 kilometres southeast of mainland France. It has hills and mountains similar to those of the Central Highlands. The island has generally poor soils and a steep, rocky coastline. Crops are grown in the valleys, and sheep graze in the mountains. See **Corsica.**

Climate

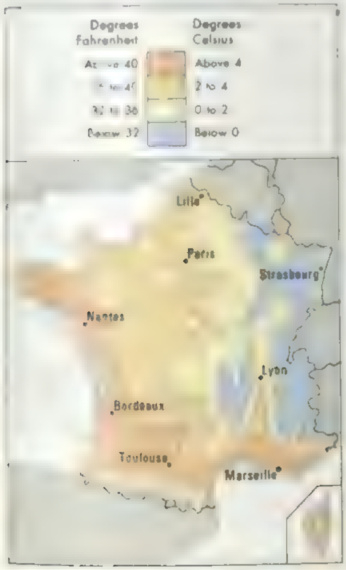
The climate varies widely among the various regions of France. The differences in climate are closely related to the distance of the land from the Atlantic Ocean or the Mediterranean Sea. Westerly winds that blow in from the Atlantic strongly influence the climate of western France. The coastal regions there have a rainy climate with cool winters and mild summers.

To the east, away from the Atlantic, the climate changes sharply between seasons. These inland regions have hot summers and cold winters, with medium rainfall throughout the year.

The mountainous regions receive the most *precipitation* (rain, melted snow, and other forms of moisture), most of it in summer. Heavy winter snows fall in the Alps and Jura Mountains, and huge glaciers are found in the Alps.

Average January temperatures

Inland regions of France have cold winters. The country's coastal regions have milder winters.

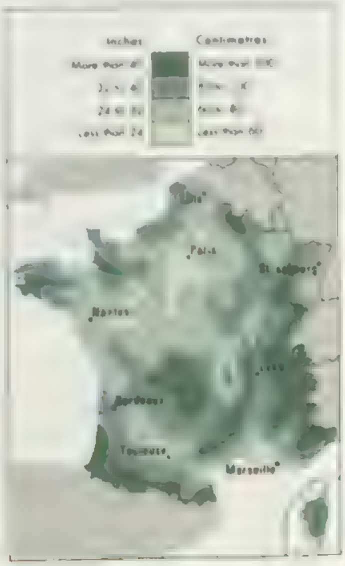


Average July temperatures

Along the Atlantic coast and in most inland regions, summers are mild. The Mediterranean coast has hot summers.

Average yearly precipitation

Mountainous regions receive the most precipitation. Inland regions and the Mediterranean coast receive the least



Average monthly weather

Paris	Temperatures °C High	Temperatures °C Low	Days of rain or snow	Marseille	Temperatures °C High	Temperatures °C Low	Days of rain or snow
Jan.	6	0	15	Jan.	12	3	10
Feb.	7	1	13	Feb.	11	3	9
Mar.	11	2	15	Mar.	13	3	8
Apr.	16	5	14	Apr.	15	5	10
May	19	8	13	May	18	8	10
June	23	11	11	June	22	11	9
July	24	13	12	July	26	14	6
Aug.	24	13	12	Aug.	28	16	4
Sept.	21	10	11	Sept.	28	16	5
Oct.	15	7	14	Oct.	24	14	7
Nov.	9	3	15	Nov.	19	10	10
Dec.	6	1	17	Dec.	15	6	11

Along the Mediterranean Sea, the lowlands have hot, dry summers and mild winters with some rainfall. Swift, cold north winds called *mistrals* sometimes blow over southern France and cause crop damage. The Alps shield the sunny Riviera from the cold north winds during much of the year.

Economy

France is a prosperous nation and its people have a high standard of living. The prosperity has resulted largely from sweeping economic changes that have been made since the 1940's. Before World War II, the French economy was based mainly on small farms and businesses. After the war ended in 1945, the French government worked to modernize the economy. New methods of production and trade were developed through a series of national plans. These improvements have brought ever-increasing production.

Most French businesses are privately owned. The government has owned all or part of some businesses, including banks, steel companies, and Renault—the largest French car manufacturer. Generally, when the Socialists have controlled the government, they have worked to increase government ownership of business. When Conservatives have been in control, they have sought to decrease government ownership.

In 1993, Conservatives gained control of the French Parliament. A law was passed that allowed the sale of most of the government-owned businesses to private owners. The exceptions included the defence, utility, and transportation and communication industries. The sale of government-owned businesses began in late 1993. The process was expected to continue over several years.

Natural resources play an important part in France's prosperity. Fertile soils are the country's most important natural resource. More than 90 per cent of France's total land area is fertile. The richest farmlands lie in the north and northeast, where wheat and sugar beet are the chief crops. The rainier northwest consists mainly of grasslands, used for grazing cattle and sheep, and orchards. Many of the drier areas of southern France have good soils for growing grapes. Soils are generally poor in the Central Highlands and on Corsica.

France has major deposits of iron ore and *bauxite* (aluminium ore). There are also deposits of coal, petroleum, natural gas, and potash. France has large areas of forests.

Service industries are those economic activities that produce services, not goods. About 60 per cent of the

workers are employed by service industries. Service industries are especially important to the Paris area.

Community, government, and personal services form the most important type of service industry. This industry employs about a third of all workers. It includes such economic activities as education and health care, government and the military, and data processing.

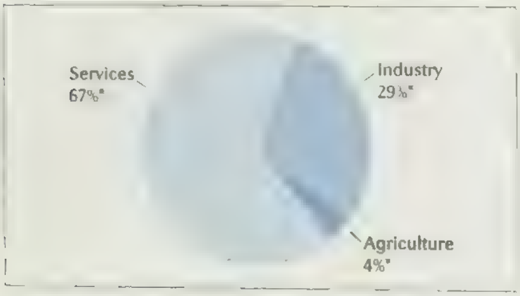
Trade, hotels, and restaurants form the second most important type of service industry in terms of employment. Paris is a major world centre for the wholesale trade of cars and chemicals. Marseille, France's main seaport, is the centre of the country's foreign trade. Lyon is a leading city in the wholesale trade of textiles. Retail trade, hotels, and restaurants are greatly aided by the large numbers of tourists that visit France.

Other service industries include finance, insurance, and property; transportation and communication; and utilities. Transportation and communication are discussed later in this section.

Manufacturing. France ranks as one of the world's leading manufacturing nations. The Paris area is the country's chief manufacturing centre, but there are factories in cities and towns throughout the country.

Tourism contributes significantly to the French economy. A *bateau-mouche* (excursion boat), *above,* carries tourists along the Seine River in Paris. Millions of tourists visit Paris every year.

France's gross domestic product



The gross domestic product (GDP) is the total value of goods and services produced within a country in a year. The GDP measures a nation's total economic performance and can also be used to compare the economic output and growth of countries. France's GDP was U.S.$1,194,201,000,000 in 1991.

Production and workers by economic activities

Economic activities	Per cent of GDP* produced	Employed workers† Number of people	Per cent of total
Manufacturing	22	4,557,000	21
Community, government, & personal services	23	6,982,000	32
Finance, insurance, & property	22	2,227,000	10
Trade, hotels, and restaurants	14	3,778,000	17
Construction	6	1,581,000	7
Transportation & communication	6	1,405,000	6
Agriculture, forestry, & fishing	4	1,257,000	6
Utilities	2	203,000	1
Mining	1	81,000	‡
Total	100	21,310,000	100

*Based on gross domestic product (GDP) in 1988. GDP is the total value of goods and services produced within a country in a year.
†Figures are for 1991
‡Less than one-half of one per cent
Sources: International Labor Organization; United Nations

France is the fourth largest producer of cars in the world, after Japan, the United States, and Germany. French cars include Renaults, Peugeots, and Citroens. Car plants are located in the Paris Basin and near Lyon, Rennes, and Douai. France also makes railway equipment and has the world's fastest trains.

France is a major manufacturer of sophisticated military and commercial aeroplanes. Toulouse is the centre of aircraft production. France has a successful space programme, and has launched rockets and communications satellites. The country also produces aerospace equipment, electronic defence systems, and many kinds of weapons. France has a fast-growing commercial electronics industry that produces computers, radios, television sets, and telephone equipment.

The chemical industry produces a variety of products from industrial chemicals to medicines and cosmetics. French plants make high-quality glass and tyres.

The French iron and steel industry uses imported iron ore as well as ore mined in France. The aluminium industry uses bauxite taken from French mines. Local and imported wood goes into the production of furniture, timber, and pulp and paper. The famous French perfume industry, based in Paris, uses flowers that are grown in southeastern France.

France is a major producer of industrial machinery, and also ranks as a leader in designing new machines. French firms perform engineering services and also construct industrial and transportation projects in many countries. France also produces machine tools and *robotic* machines that perform repeated tasks in factories.

Cotton and silk textiles have long been important French products. French plants also produce nylon and other artificial fibres. The Lyon area, long a centre for manufacturing silk, also has artificial-fibre factories. Paris, the fashion capital of the world, produces much of the country's clothing.

Food processing employs many French people. Famous French foods include breads, meats, fruit preserves, and especially wines and cheeses. France ranks as the world's second largest wine-producing country, after Italy. The wines are aged in deep cellars or caves. France produces butter and about 400 kinds of cheeses, including Brie, Camembert, and Roquefort. France also is among the world's leading producers of sugar.

Agriculture. France is Western Europe's largest agricultural producer and one of the world's leading exporters of farm products. Almost all French farms have electricity, and most have modern farm machinery. French farms average 28 hectares in size. About two-thirds of French farm income comes from meat and dairy animals. About a fourth of the land consists of grassland used for grazing. Beef cattle are the chief meat animals, and lambs and sheep are also important. Much of the milk produced on dairy farms is used in making butter and cheese. French farmers have always raised some poultry and pigs, and specialized, large-scale production of these animals is expanding rapidly.

Crops grow on more than a third of France's land. Large farms in the Paris Basin and the north grow most of the wheat, France's leading single crop. Most grapes used in making wine are grown in southern France. Grapes for high-quality wines come from several regions, including Alsace, Bordeaux, Burgundy, Champagne, and the Loire Valley. The Mediterranean region produces grapes used for cheaper wines. Each region produces grapes that have their own special flavour. Grapes from southwestern France are used in brandy.

Car production is one of France's leading industries. Workers build engines in a Renault factory, *above*.

Apple orchards dot many areas of northern France, especially Normandy. Potatoes, sugar beet, and such livestock-feed crops as barley, maize, oats, and rapeseed are major crops. Other important French crops include beans, carrots, cauliflower, cherries, flowers, peas, peaches, pears, sunflower seeds, and tomatoes.

Economy of France

This map shows the economic uses of land in France. It also indicates the country's main farm products, its chief mineral deposits, and its most important fishing products. Major manufacturing centres are shown in red.

Mostly cropland
Cropland mixed with grazing land
Mostly grazing land
Forest land
Generally unproductive land
Fishing
• Manufacturing centre
• Mineral deposit

France produces more wine than any other country except Italy. Wooden barrels hold the wine for aging, *above.* A wine tester, on the left, uses a *wine thief* to draw a sample

Forestry. Forests cover about a quarter of France. Heavily forested areas include the Northeastern Plateaus, the Central Highlands, the southwest coastal areas, and the slopes of the Alps, Juras, Pyrenees, and Vosges. Many forests have been planted in the Landes area of southwestern France for use by the pulp and paper industry. Cork oaks, pine trees, and olives grow along the dry Mediterranean coast and on Corsica. Forest fires are common in these regions. Other trees of France include ashes, beeches, and cypresses.

Mining. Iron ore is France's most important mineral deposit. Most of it comes from Lorraine, and is used in the region's steel industry. Deposits of bauxite, from which aluminium is made, are found in southeastern France. Bauxite was named after the town of Les Baux in the producing area. Alsace has considerable reserves of potash, a substance used in making fertilizers. Discoveries of natural gas at Lacq, in southwestern France, have attracted many industries. French mines also yield gypsum, salt, sulphur, tungsten, and uranium.

Fishing. French commercial fishing brings in a yearly catch of about 680,000 metric tons. Fishing crews work off the French coasts, or sail to the waters of Iceland and Newfoundland, Canada. Many fleets operate from Brittany and Normandy. Seafood taken includes cod, crabs, lobsters, monkfish, mussels, oysters, pollock, sardines, scallops, tuna, and whiting.

Energy sources. Nuclear power plants provide more than half of France's electricity. France is a world leader in nuclear energy technology and in the production of nuclear fuels. Most of the rest of France's electric power is generated by coal-burning plants or by hydroelectric power. The Alps and the Jura Mountains have many hydroelectric plants.

In 1966, the French government began operating the world's first tidal power plant. It uses the tides in the mouth of the Rance River in Brittany. These tides are among the highest in the world, and may reach a height of 13 metres. A solar power plant operates in the Pyrenees.

Foreign trade of France, as measured by exports, ranks fifth in the world after the United States, Germany, Japan, and the United Kingdom (UK). The value of France's imports is slightly higher than the value of its exports. France's major imports are petroleum products. Its major exports include chemical products, machinery, electrical equipment, and cars. France belongs to the European Union, also called the European Common Market (see **European Union**). About half of France's trade is with European Union countries, mainly Germany. France's major trading partners outside the European Union include Japan, Switzerland, and the United States.

Transportation. Since the 1700's, France has had more road mileage in relation to its size than any other European country. Today, it has a fine road system, including many multilane motorways. Most French households own at least one car. Two of the world's longest road tunnels link France and Italy. One, 13.0 kilometres long, cuts through Fréjus Peak. The other, 11.7 kilometres long, cuts through Mont Blanc. In 1994, a tunnel beneath the English Channel was opened. The tunnel links France and the UK by rail (see **Channel Tunnel**).

The French railway system, owned and operated by the government, provides excellent passenger and freight services. The rail network forms a cobweb pattern, with Paris as the hub. A railway tunnel through Fréjus Peak links France with Italy. In 1981, a high-speed electric train began operating between Paris and Lyon. Called the TGV (*train à grande vitesse,* or high-speed train), it reaches speeds of up to about 270 kilometres per hour. Today, it also links Paris to several cities in Switzerland. In 1989, a faster TGV began operation between Paris and other cities in France. A top speed of 300 kilometres per hour makes it the world's fastest passenger train.

Charles de Gaulle and Orly airports, both near Paris, rank among the world's busiest airports. Other major airports include Marseille, Nice, and Lyon. Air France, an airline jointly owned by the French government and private investors, serves about 75 countries. Another airline, Air Inter, provides a service among the large cities of France. Air Inter is fully owned by the government.

France's TGV (*train à grande vitesse,* or high-speed train) began operating between Paris and Lyon in 1981.

Ships and barges operate on navigable rivers and canals throughout France. These rivers include the Rhine, Rhône, and Seine. Northern and eastern France have well-developed canal systems. Oceangoing ships dock at many fine French seaports. The country's busiest seaports are Marseille, Le Havre, and Dunkerque.

Communication. France has about 85 daily newspapers, representing a wide range of political opinions. The largest newspaper, *Ouest-France* of Rennes, prints about 45 different editions, each with local news. Other major daily newspapers include *Le Figaro, France-Soir, Le Monde, Libération,* and *Le Parisien Liberé* of Paris; *Sud-Ouest* of Bordeaux; *La Voix du Nord* of Lille; *Le Progrès* of Lyon; *Le Provençal* of Marseille; and *Le Dauphiné Libéré* of Grenoble. Major weekly news magazines include *L'Express* and *Le Nouvel Observateur.*

France has several television and radio networks, most of which are operated by independent government agencies. The broadcasting system's income is largely provided by annual taxes on radios and television sets. Almost all French households possess at least one radio and most own a television set.

A government agency supervises France's film industry. The agency's activities include giving financial aid to producers, especially of experimental films and films of serious dramatic value. The annual Cannes Film Festival, in Cannes, is the world's largest international film event. There are about 4,700 cinemas throughout the country.

History

Early days. In ancient times, tribes of Celts and other peoples lived in what is now France. The Romans called the region *Gallia* (Gaul). Roman armies began to invade Gaul in about 200 B.C. By 121 B.C., Rome controlled the Gallic land along the Mediterranean Sea and in the Rhône Valley. Julius Caesar conquered the entire region between 58 and 51 B.C. The people, called *Gauls,* soon adopted Roman ways of life. They used the Latin language of the invaders. Gaul prospered under Roman rule for hundreds of years, in spite of barbarian invasions during the A.D. 200's and 300's. See **Celts; Gaul.**

Victory of the Franks. The border defences of the West Roman Empire began to crumble in the A.D. 400's. Germanic tribes from the east, including Burgundians, Franks, and Visigoths, crossed the Rhine River and entered Gaul. They killed many Gauls and drove others west into what is now Brittany. Clovis, the king of the Salian Franks, defeated the Roman governor of Gaul in 486 at Soissons. Clovis then defeated other Germanic tribes in Gaul, and extended his kingdom. He founded the Merovingian *dynasty* (a series of rulers from the same family), and adopted Christianity. See **Clovis I; Franks; Merovingian.**

The rise of manorialism and feudalism. From the 600's to the 1000's, during the chaotic years of the early Middle Ages, manors covered much of France. Manors were large estates governed by owners called *landlords* or *lords,* who offered military protection to peasants called *serfs.* Manorialism was a system of organizing agricultural labour. See **Manorialism; Serf; Middle Ages.**

A political and military system called feudalism began to appear in the 700's. A feudal lord gave his subjects land in return for military and other services. Both the lord and his subjects, called *vassals,* were aristocrats. The land granted by a lord was called a *fief.* Some small fiefs supported only one vassal. Other fiefs were quite large, such as the province of Normandy. Manorialism and feudalism thrived until the 1100's. See **Feudalism.**

The Carolingian dynasty. By the mid-600's, the Merovingian kings had become weak rulers, interested mainly in personal pleasures. Pepin of Herstal, the chief royal adviser, gradually took over most of the royal powers. His son, Charles Martel, extended the family's power. He received the title of *Martel* (the Hammer) after defeating an invading Arab army in 732. The battle began near Tours and ended near Poitiers. Charles Martel became king of the Franks in all but title. See **Charles Martel.**

Charles Martel's son, Pepin the Short, overthrew the last Merovingian ruler and became king of the Franks in 751. He founded the Carolingian dynasty, and enlarged the Frankish kingdom. Pepin also helped develop the political power of the pope by giving Pope Stephen II a large gift of land north of Rome. See **Papal States; Pepin the Short.**

Pepin's son, Charlemagne, was one of the mightiest conquerors of all time. After Charlemagne became king of the Franks, he went on more than 50 military campaigns and expanded his kingdom far beyond the borders of what is now France. He also extended the pope's lands. In 800, Pope Leo III crowned Charlemagne Emperor of the Romans. For the story of Charlemagne and a map of his empire, see **Charlemagne.**

Charlemagne died in 814, and his three grandsons later fought among themselves for control of his huge empire. They divided it into three kingdoms in 843. In the Treaty of Verdun, one grandson, Charles the Bald, received most of what is now France. The second kingdom consisted of much that is now Germany. The third kingdom lay between the other two. It consisted of a strip of land extending from the North Sea to central Italy. The middle kingdom north of Italy was divided between the other two in 870. See **Verdun, Treaty of.**

Kings and emperors of France

Ruler	Reign	Ruler	Reign
* Hugh Capet	987-996	* Louis XI	1461-1483
Robert II	996-1031	* Charles VIII	1483-1498
* Henry I	1031-1060	* Louis XII	1498-1515
Philip I	1060-1108	* Francis I	1515-1547
Louis VI	1108-1137	* Henry II	1547-1559
Louis VII	1137-1180	* Francis II	1559-1560
* Philip II	1180-1223	* Charles IX	1560-1574
Louis VIII	1223-1226	* Henry III	1574-1589
* Louis IX	1226-1270	* Henry IV	1589-1610
Philip III	1270-1285	* Louis XIII	1610-1643
* Philip IV	1285-1314	* Louis XIV	1643-1715
Louis X	1314-1316	* Louis XV	1715-1774
John I	1316	* Louis XVI	1774-1792
Philip V	1316-1322	* Napoleon I	1804-1814
* Charles IV	1322-1328	* Louis XVIII	1814-1815
* Philip VI	1328-1350	* Napoleon I	1815
John II	1350-1364	* Louis XVIII	1815-1824
* Charles V	1364-1380	* Charles X	1824-1830
* Charles VI	1380-1422	* Louis Philippe	1830-1848
* Charles VII	1422-1461	* Napoleon III	1852-1870

*Has a separate biography in *World Book.*

Silver and gold statue encrusted with emeralds and rubies by an unknown sculptor (about 1349); Aachen Cathedral, Germany

Charlemagne was the most famous ruler of the Middle Ages. He became king of the Franks in 768. He went on to conquer much of western Europe and unite it under one great empire.

Capetian France in 1328 consisted of royal lands—those that were the personal holdings of the king—and lands held by French nobles who were vassals of the king.

The Capetian dynasty. By the late 900's, the Carolingian kings had lost much of their former power, and the strength of the nobles had greatly increased. The kings had become little more than great feudal lords chosen by the other feudal nobles to lead them in time of war. But in peacetime, most of a king's authority extended over only his personal estates. In 987, the nobles ended the Carolingian line of kings and chose Hugh Capet as their new king. Capet started the Capetian dynasty. Many historians mark the beginning of the French nation from the coronation of Hugh Capet. See **Capetian dynasty; Hugh Capet.**

Important dates in France

58-51 B.C. Julius Caesar conquered Gaul.
A.D. 486 Clovis, a king of the Franks, defeated the Roman governor of Gaul.
800 Charlemagne became emperor of the Romans.
987 Hugh Capet was crowned king of France.
1302 Philip IV called together the first Estates-General, the ancestor of the French Parliament.
1309-1377 The popes lived in Avignon.
1337-1453 France defeated England during the Hundred Years' War.
1598 Henry IV issued the Edict of Nantes, which gave limited religious freedom to Protestants.
1643-1715 Louis XIV ruled France, and consolidated the absolute authority of the French king.
1789-1799 The French Revolution took place. It ended absolute rule by French kings.
1792 The First Republic was established.
1799 Napoleon seized control of France.
1804 Napoleon founded the First Empire.
1814 Napoleon was exiled; Louis XVIII came to power.
1815 Napoleon returned to power, but was defeated at Waterloo. Louis XVIII regained the throne.
1848 Revolutionaries established the Second Republic.
1852 Napoleon III founded the Second Empire.
1870-1871 Prussia defeated France in the Franco-Prussian War. The Third Republic was begun.
1914-1918 France fought on the Allied side in World War I.
1939-1940 France fought on the Allied side in World War II until defeated by Germany.
1940-1942 Germany occupied northern France.
1942-1944 The Germans occupied all France.
1946 France adopted a new constitution, establishing the Fourth Republic.
1946-1954 A revolution in French Indochina resulted in France's giving up the colony.
1949 France joined the North Atlantic Treaty Organization (NATO).
1954 Revolution broke out in the French territory of Algeria.
1957 France joined the European Community, now called the European Union.
1958 A new constitution was adopted, establishing the Fifth Republic. Charles de Gaulle was elected president.
1962 France granted independence to Algeria.
1966 De Gaulle withdrew French troops from NATO.
1969 De Gaulle resigned as president.
1981 Socialist victories in presidential and parliamentary elections resulted in France's first leftist government since 1958.
1994 A railway tunnel under the English Channel between France and England opened.
1995 France elected a right-wing president following a conservative victory in parliamentary elections two years earlier.

For many years, the Capetian kings controlled only their royal *domain* (land), between Paris and Orléans. The great feudal nobles ruled their own domains almost independently. The dukes of Normandy were the most powerful of these nobles. Normandy became the most unified and best administered feudal state in Europe. In 1066, the Norman Duke William, later called William the Conqueror, invaded England and became king. See **Norman Conquest; William** (I, the Conqueror).

Growth of royal power. The Capetian kings gradually added more territory to their personal lands, and became stronger than any of their rivals. In addition, every Capetian king for over 300 years had a son to succeed him on the throne. As a result, the nobles' power to select kings died out. The nobles were further weakened because many of them left France between 1100 and 1300 on crusades to capture the Holy Land from the Muslims. See **Crusades.**

Philip II, called Philip Augustus, was the first great Capetian king. After he came to the throne in 1180, he more than doubled the royal domain, and tightened his control over the nobles. Philip built up a large body of government officials, many of them from the middle classes in the towns. He also developed Paris as a permanent, expanding capital. See **Philip** (II) of France.

The handsome Philip IV, called Philip the Fair, rebelled against the pope's authority. He taxed church officials, and arrested a bishop and even Pope Boniface VIII. Philip won public approval for his actions in the first Estates-General, a body of Frenchmen that he called together in 1302. This group was the ancestor of the French Parliament. In 1305, through Philip's influence, a French archbishop was elected pope and became Pope Clement V. In 1309, Clement moved the pope's court from Rome to Avignon, where it remained until 1377. See **Philip** (IV); **Pope** (The troubles of the papacy).

Social conditions in Capetian France. By the 1100's, an economic revival in Europe had put money back into use. Towns, which had lost their importance under manorialism and feudalism, sprang up near main trade routes. At first, towns were self-governing. Merchants and craftworkers settled in the towns and formed organizations called *guilds*. Guilds played an important role in town government (see **Guilds**). As royal government grew, towns became judicial and administrative centres, as well as manufacturing and trading centres.

Although many people moved to the towns in search of jobs, much of the population stayed in the countryside. Agricultural methods were too primitive to support more than a very small nonagricultural population. Thus, people were still needed on farms to produce food. In both towns and the country, life expectancy was short. Many children died before reaching the age of five.

A period of wars. The last king of the Capetian dynasty, Charles IV, died in 1328 without a male heir. A cousin succeeded him as Philip VI and started the Valois dynasty. King Edward III of England, a nephew of the last Capetian king, also claimed the French throne. In 1337, Edward landed an army in Normandy. This invasion started a series of wars between France and England known as the Hundred Years' War (1337-1453). The English won most of the battles. But the French, after their victory at Orléans under Joan of Arc, drove the English out of most of France. See **Hundred Years War; Joan of Arc, Saint; Valois.**

Louis XI laid the foundations for absolute rule by French kings. During the Hundred Years' War, the kings had lost much of their power to the French nobles. Louis regained this power. His greatest rival was Charles the Bold, Duke of Burgundy. Charles died in battle in 1477 while trying to conquer the city of Nancy, and Louis seized most of his vast lands. See **Louis** (XI).

Francis I invaded northern Italy, and captured Milan in 1515. In a later Italian campaign, Francis was defeated by Charles V of the Holy Roman Empire. French wars against the Holy Roman Empire continued into the reign of Henry II. The Empire and England were allies. In 1558, this alliance gave Henry an excuse to seize the port city of Calais, England's last possession in France. See **Francis** (I) of France; **Henry** (II) of France.

Religious wars. During the early 1500's, a religious movement called the Reformation developed Protestantism in Europe. Many French people became Protestants. They followed the teachings of John Calvin, and were called *Huguenots*. After 1540, the government persecuted the Huguenots severely, but they grew in number and political strength. In the late 1500's, French Roman Catholics and the Huguenots fought a series of civil wars that lasted over 30 years. In 1572, thousands of Huguenots were killed during the Massacre of Saint Bartholomew's Day. See **Calvin, John; Huguenots.**

Henry III died in 1589 without a male heir. He was followed by Henry of Navarre, who became Henry IV and started the Bourbon dynasty. But Roman Catholic forces prevented him from entering Paris because he was the leader of the Huguenots. In 1593, Henry became a Roman Catholic to achieve peace. He entered the capital the next year. In 1598, Henry signed the Edict of Nantes, which granted limited freedom of worship to the Huguenots. See **Bourbon; Henry** (III and IV) of France.

The age of absolutism. The power of the kings and their *ministers* (high government officials) grew steadily from the 1500's to the 1700's. France became strong, largely through the efforts of these ministers. The first important minister was Maximilien de Béthune, Duke of Sully, who served Henry IV. Sully promoted agriculture and such public works as roads and canals. He reduced the *taille*, the chief tax on the common people. The actual ruler behind Louis XIII was his prime minister, Armand Jean du Plessis, Cardinal Richelieu. Richelieu increased royal power more than any other individual. See **Richelieu, Cardinal.**

Louis XIV was the outstanding example of the absolute French king. He is said to have boasted: "I am the State." After his prime minister died in 1661, Louis declared that he would be his own prime minister. In 1685, Louis cancelled the Edict of Nantes and began to persecute the Huguenots savagely. About 200,000 Huguenots fled France, which weakened the country's economy. Louis' minister of finance, Jean Baptiste Colbert, promoted a strong economy. But the construction of Louis' magnificent palace at Versailles and a series of major wars drained France's finances. Louis tried to rule supreme in Europe. He was stopped by military alliances that included England, Spain, the Holy Roman Empire, and other countries. See **Grand Alliance; Louis XIV; Succession wars** (The war of the Spanish succession).

The gathering storm. By the 1700's, a government bureaucracy had developed to manage a large standing royal army, as well as to collect taxes. Royal courts upheld law and order. Lawyers and jurists bought their offices from the king at very high prices. The king allowed those who bought the highest judicial offices to call themselves nobles, and he granted them tax exemptions.

This burdensome system worked well enough to allow remarkable economic and population growth in the 1700's. But the population growth exceeded agriculture's production capacities, and food shortages and famines became common. Such growth also strained the guild system that governed the activities of merchants and craftworkers in the towns.

Burdened by the needs of the military and unable to tax nobles or church lands, the government was forced to borrow heavily. In 1786, the government proposed a new land tax in order to avoid bankruptcy. Many urban lawyers, merchants, clerks, and craftworkers, as well as some aristocrats, opposed any new taxes. The French Revolution was born out of this crisis.

The French Revolution. To win support for new taxes, King Louis XVI called a meeting of the Estates-General. The Estates-General was made up of representatives from the three *estates,* or classes—the clergy, the nobility, and the commoners. It opened on May 5, 1789, at Versailles, near Paris. In June 1789, members of the third estate—the commoners—declared themselves a National Assembly, with full power to write a new constitution for France. The third estate had as many representatives as the other two estates combined.

At first, Louis XVI delayed taking action and began gathering troops around Paris to break up the Assembly. However, many French people organized an armed resistance movement in Paris. On July 14, 1789, a huge crowd of Parisians captured the royal fortress called the Bastille. Louis XVI was forced to give in. By September 1791, the Assembly had drafted a new constitution that made France a constitutional, or limited, monarchy, with a one-house legislature.

Storming of the Bastille (about 1800), an oil painting on canvas by an unknown artist; Château Versailles, France

The storming of the Bastille on July 14, 1789, was an early event in the French Revolution. A huge crowd of Parisians captured the fortress, forcing royal troops to withdraw from Paris.

The new government did not last long. In April 1792, France went to war against Austria and Prussia. These countries wished to restore the king to his former position. In the summer of 1792, as foreign armies marched on Paris, revolutionaries imprisoned Louis XVI and his family and overthrew the monarchy. A National Convention, chosen through an election open to almost all adult French males, opened on Sept. 21, 1792, and declared France a republic.

Civil and foreign wars pushed the new republican government to extreme and violent measures. Radical leaders such as Maximilien Robespierre gained power. They said that terror was necessary to preserve liberty. Thus, while the revolution survived under radical leadership, it also sentenced many "enemies of the republic" to death. Thousands of people were executed. In time, the radicals began to struggle for power among themselves. Robespierre was condemned by his enemies and executed. His death marked the end of the period called the Reign of Terror. See **Robespierre.**

In 1795, a new constitution was adopted that formed a government called the Directory. The Directory, a five-man board, governed France from 1795 to 1799, during the last half of the French Revolution. For more details on the causes, violence, and reforms of the French Revolution, see **French Revolution.**

Napoleon. During the French Revolution, a young officer named Napoleon Bonaparte rose through the ranks of the army. He was named a general in 1793, and his power grew rapidly. In 1799, Napoleon overthrew the revolutionary French government and seized control of France. Napoleon was an excellent administrator. He created a strong, efficient central government and revised and organized French law. He was also a military genius with great ambition. By 1812, Napoleon's forces had conquered most of western and central Europe. But maintaining control over this vast empire eventually overextended French power, and Napoleon was forced to give up his throne in 1814. He returned to rule France again for about three months in 1815 before his final defeat at Waterloo. For the story of Napoleon's life and a map of his empire, see **Napoleon I.**

The revolutions of 1830 and 1848. The Bourbon dynasty returned to power after Napoleon's downfall. Charles X, who became king in 1824, tried to reestablish the total power of the earlier French kings. He was overthrown in the July Revolution of 1830. See **Charles** (X) of France; **July Revolution; Louis** (XVIII).

The revolutionaries placed Louis Philippe on the throne. He belonged to the Orléans branch of the Bourbon family. France was peaceful and prosperous during Louis Philippe's reign. But the poorer classes became dissatisfied because only the wealthy could vote or hold public office. The February Revolution of 1848 overthrew the government and established the Second Republic. All Frenchmen received the right to vote. See **Louis Philippe; Revolution of 1848.**

The voters elected Louis Napoleon Bonaparte, a nephew of Napoleon, to a four-year term as president in 1848. He seized greater power illegally in 1851, and declared himself president for 10 years. In 1852, he estab-

lished the Second Empire and declared himself Emperor Napoleon III. See **Napoleon III.**

The Franco-Prussian War. During the 1860's, France became alarmed over the growing strength of Prussia. France feared that a united Germany under Prussian leadership would upset Europe's balance of power. After a series of disputes, France declared war on Prussia in 1870. Prussia defeated France the next year. In the peace treaty following the war, France was forced to give almost all of Alsace and part of Lorraine to the new German Empire. See **Franco-Prussian War.**

The Third Republic. After Prussian victories in 1870, the French revolted against Napoleon III. They established a *provisional* (temporary) republic, which became known as the Third Republic, and in 1871 elected a National Assembly. In 1875, the Assembly voted to continue the republic, and wrote a new constitution.

French strength and prosperity grew until World War I began in 1914. French explorers and soldiers won a vast colonial empire in Africa and Asia. Only Great Britain had a larger overseas empire. France strengthened its army, and formed a military alliance with Russia in 1894 and the *Entente Cordiale* (cordial understanding) with Great Britain in 1904. French industries expanded steadily, especially after 1895.

By the 1890's, most French people were reconciled to the Third Republic, but few were deeply committed to it. An incident known as the Dreyfus affair finally forced the nation to take sides on this issue. On Oct. 15, 1894, Alfred Dreyfus, a Jewish French army officer, was arrested on suspicion of spying for Germany. In December, a military court found him guilty. Evidence of his innocence slowly trickled out and eventually attracted much attention. Many people began to rally to Dreyfus' side. They included Socialists representing the French working class, moderate republicans, and other people with no political background.

These people believed that the French army had acted arbitrarily in convicting Dreyfus and feared that the republic was endangered. They made Dreyfus a symbol of civil liberties and republican virtues and worked to get him a new trial. Opponents of republican government and army supporters came together and denounced Dreyfus and his supporters as antipatriotic. A fight followed that resulted in a strengthening of support for the republic. In 1906, France's highest court reviewed the Dreyfus case and declared Dreyfus innocent. See **Dreyfus, Alfred.**

World War I. During the early 1900's, France and Germany had disagreements over colonial territories, and each country feared an attack by the other. In 1907, France established a diplomatic agreement called the Triple Entente with Great Britain and Russia. The French prepared for war. Soon after the start of World War I (1914-1918), Germany invaded France. The Germans hoped to defeat France quickly. But by late 1914, the French army had halted the German advance. For $3\frac{1}{2}$ years, the opposing forces fought from trenches that stretched across northeastern France and Belgium.

The worst fighting faced by the French army during the war took place around the city of Verdun in 1916. In February, the German army launched a major attack to take Verdun. For five months, intense fighting involved hundreds of thousands of troops. At first, the Germans made rapid progress. But they were slowly rolled back. In July, the Germans halted their unsuccessful attack.

The Battle of Verdun became a symbol of France's will to resist. But the battle had also drained the country. From the middle of 1917, France's allies began handling most of the war's major battles. The war produced enormously high casualties, partly as a result of the destructive powers of new weapons such as the machine gun and poison gas. Millions of French servicemen were killed or wounded. For more on the story of France in the war, see **World War I.**

Between the World Wars. In the Treaty of Versailles, signed in 1919, France recovered Alsace and the German part of Lorraine from Germany. France and other Allied nations also were awarded *reparations* (payments for war damages) from Germany. Germany fell behind in making these payments. As a result, French and Belgian troops occupied the Ruhr Valley of Germany in 1923. After Germany agreed to keep up the payments, the troops were withdrawn in 1925. See **Alsace-Lorraine; Ruhr** (History); **Versailles, Treaty of.**

The French did much to reestablish good relations with Germany. France joined other Allied nations and Germany in the Rhineland Security Pact of 1925. This agreement in part guaranteed the security of the French-German border. France reduced Germany's reparations, and dropped various controls over Germany set up by the Treaty of Versailles. Suggestions by Aristide Briand, the French foreign minister, led to the Kellogg-Briand Peace Pact of 1928 (see **Kellogg-Briand Peace Pact**). It was signed by France, Germany, and 13 other countries. But in 1929, France began building the Maginot Line as a fortified defence against Germany.

During the 1930's, the worldwide economic depression and the rise of fascist leader Adolf Hitler in Germany caused serious political unrest in France. In 1936, at a time of widespread strikes, a government called the Popular Front came to power in France. It made many promises to striking workers and tried to establish a strong position against fascism. But in 1938, the government began to give in to the demands of Nazi Germany. As part of this policy of *appeasement,* France signed the Munich Agreement, which forced Czechoslovakia to give territory to Germany (see **Munich Agreement**).

World War II began when Germany invaded Poland on Sept. 1, 1939. Two days later, France and Great Britain declared war on Germany. On May 10, 1940, the Germans attacked Belgium, Luxembourg, and the Netherlands. They invaded France through Belgium on May 12, passing northwest of the Maginot Line. The Germans launched a major attack to the south on June 5, and entered Paris on June 14. On June 22, France signed an armistice with Germany. The Germans occupied the northern two-thirds of France, and southern France remained under French control. Southern France was governed at Vichy by Marshal Henri Philippe Pétain, who largely cooperated with the Germans. See **Pétain, Henri Philippe.**

After France fell, General Charles de Gaulle fled to London. He invited all French patriots to join a movement called *Free France,* and continue fighting the Germans. This *resistance* movement spread throughout France. Some groups of French people called *Maquis* hid in hilly areas and fought the Germans. After Allied troops landed in French North Africa in November 1942,

France in World War II. Germany occupied northern France from 1940 to 1944. Southern France remained under French control, with its capital at Vichy, until 1942, when it was occupied.

Allied troops rode through Paris on Aug. 26, 1944, the day after they freed the city from Nazi occupation in World War II. French citizens crowded the streets to welcome the troops.

German troops also occupied southern France. The Germans tried to seize the French fleet at Toulon. But the French sank most of the fleet's ships to prevent them from being captured by the Germans. See **De Gaulle, Charles; Maquis.**

On June 6, 1944, the Allies landed in France at Normandy. They landed in southern France on August 15. After fierce fighting and heavy loss of lives, the Allied troops entered Paris on August 25. De Gaulle soon formed a provisional government and became its president. In 1945, France became a charter member of the United Nations. For the story of France in the war, see **World War II.**

The Fourth Republic. In October 1945, the French people voted to have the National Assembly write a new constitution creating the Fourth Republic. In this election, French women voted for the first time. De Gaulle resigned as president in January 1946, over disagreements with the Assembly. The new constitution, much like that of the Third Republic, went into effect in October 1946. De Gaulle opposed it because it did not provide strong executive powers.

France received considerable aid from the United States, and rebuilt its cities and industries, which had been badly damaged during the war. But political troubles at home and colonial revolts overseas slowed the country's economic recovery. France played an important part in the Cold War between the Communist countries and the Western countries (see **Cold War**). The Communist Party was one of the largest in France after the war, and it controlled the chief trade unions. Communist-led strikes in 1947 and 1948 crippled production across the country. But in 1949, France became a charter member of the anti-Communist North Atlantic Treaty Organization (NATO).

The first revolt by a French colony began in Indochina in 1946. Indochina was eventually divided into Cambodia, Laos, and North and South Vietnam. The French withdrew from Indochina in 1954 after heavy losses. See **Indochina** (French Indochina).

Later in 1954, revolution broke out in the French territory of Algeria. To prevent revolutions in Morocco and Tunisia, France made them independent in 1956. Other French colonies in Africa received independence later. But France refused to give up Algeria, the home of almost a million French settlers. France gradually built up its army in Algeria to about 500,000 men, and the war continued throughout the 1950's. See **Algeria** (The Algerian Revolution).

In spite of the costly colonial wars, France's economy grew rapidly. By the late 1950's, it had broken all French production records. The boom developed with U.S. aid and a series of national economic plans begun in 1946. French businessmen and government officials were determined to prove that France's greatness had not disappeared. Between 1947 and 1958, France helped form several economic organizations that were important steps toward a European confederation. For discussions of these organizations, see **Europe, Council of; European Union.**

The Fifth Republic. By 1958, large numbers of French people thought it was useless to continue fighting in Algeria. But the idea of giving up Algeria angered many French army leaders and settlers in the colony. They rebelled in May 1958 and threatened to overthrow the French government by force unless it continued fighting. In a compromise solution, de Gaulle was called back to power as prime minister, with emergency powers for six months. His government prepared a new constitution, which the voters approved on Sept. 28, 1958. This constitution, which established the Fifth Republic, gave the president greater power than ever before and sharply reduced the power of Parliament. In December, the Electoral College elected de Gaulle to a seven-year term as president.

France under de Gaulle. De Gaulle's government continued the war in Algeria, hoping the Algerians

would agree to a compromise settlement that provided some French control. By 1961, however, the government realized that only Algerian independence would end the rebellion. Peace talks began in 1961 and ended with a cease-fire in March 1962. At de Gaulle's urging, French voters approved Algerian independence in April. Algeria became independent on July 3, 1962, and most French settlers there returned to France.

Algerian independence set off a wave of bombings and murders in France and Algeria by the Secret Army Organization (OAS). This group, which included many army officers, accused de Gaulle of betraying France by ending the war. The OAS tried several times to kill de Gaulle. Its leaders were eventually captured and sentenced to terms of imprisonment.

After the Algerian crisis, some French politicians tried to weaken de Gaulle's strong rule. They wanted to re-establish the former power of Parliament and reduce that of the president. But de Gaulle made the presidency even stronger. He declared that the president should have nationwide support and be elected by the people, not by the Electoral College. In 1962, the voters approved a constitutional amendment that provided for such elections.

De Gaulle was reelected to a second seven-year term in 1965. French foreign policy became his main interest. De Gaulle declared that the French were "a race created for brilliant deeds," but that they could not achieve greatness with their "destiny in the hands of foreigners." He hoped to make France the leader of an alliance of Western European countries. This alliance would be free of U.S. or Soviet influence. Instead of relying on American protection through NATO, de Gaulle developed an independent French nuclear-weapons programme. In 1966, de Gaulle removed all French troops from NATO. He also declared that all NATO military bases and troops had to be removed from France by April 1967. France withdrew from NATO militarily, but it remained a member politically.

In 1957, France and other Western European nations formed the European Community, also called the European Common Market. De Gaulle believed France could work within this economic organization to become stronger and more influential in Western Europe. In 1963, he prevented Great Britain from joining the Common Market. He considered Britain a rival for leadership in Western Europe. He also believed Britain's ties with the United States would give America too much influence on Europe's economy.

In the late 1960's, many French people became dissatisfied with de Gaulle's government. This dissatisfaction led to a severe national crisis in May 1968. Students staged demonstrations in Paris, some of which erupted into violent clashes with the police. Demonstrations, many accompanied by violence, spread throughout France, and millions of workers joined in by going on strike. The country was paralysed for more than two weeks, and many people expected the overthrow of de Gaulle's government and possible civil war. But de Gaulle managed to bring the situation under control by the end of May. He called a general election in June, and his supporters won more than 70 per cent of the seats in Parliament. However, de Gaulle's reputation as a leader had been seriously damaged by what the French called the "events of May." In April 1969, de Gaulle asked for minor constitutional reforms and said he would resign if the voters did not approve them. The French people voted against the reforms, and de Gaulle resigned.

France after de Gaulle. Georges Pompidou was elected president in June 1969. He had been de Gaulle's prime minister, and he promised to continue de Gaulle's policies. But Pompidou changed de Gaulle's foreign policies by cooperating more closely with the United States. He also improved relations with Great Britain. In 1971

France's empire France's colonial empire spanned two eras. From the early 1600's to the 1760's, France built a vast empire in North America. From the 1800's to the mid 1900's, France held many colonies in Africa and Asia. The names of the remaining French overseas possessions are underlined on the map.

Charles de Gaulle served as president of France from 1958 to 1969. He greatly increased the power of the presidency, particularly in the conduct of foreign policy.

Pompidou and British Prime Minister Edward Heath agreed on Britain's entry into the Common Market.

At home, Pompidou's government faced economic problems. The country's industrial growth began to slow down, unemployment increased, and inflation rose to a high level. Part of the economic trouble resulted from the worldwide oil crisis in 1973. Oil-producing countries raised the price of oil sharply, and France was seriously affected because it imports most of its petroleum.

Pompidou died in April 1974. The Gaullist Party, which had supported de Gaulle and Pompidou, split into a number of separate groups in the presidential election that followed in May. These groups supported various candidates. As a result, the Gaullist Party was weakened. Valéry Giscard d'Estaing, head of the Independent Republican Party, was elected president.

The Gaullists and a group of parties that supported Giscard won a majority of the seats in French parliamentary elections held in 1978. Those parties formed a coalition government. The leftist Socialist and Communist parties were their main opponents.

The loss of most of its colonial empire has relieved France of the cost of governing and developing the colonies. However, France still gives economic, technical, and military aid to many of its former colonies.

Recent developments. Politically, France moved sharply to the left in 1981. The voters elected François Mitterrand of the Socialist Party as president. In addition, the Socialists won a majority of the seats in parliamentary elections held in 1981. The elections gave France its first leftist government since 1958. Moderates and conservatives had controlled all the governments since then. Under the moderates and conservatives, the government owned some French businesses. The new Socialist leaders greatly increased government ownership of businesses.

From the time of Napoleon I, France's departments were administered by prefects—officials appointed by, and responsible to, the national government. But the Socialist government gave locally elected councils responsibility for the departments. In 1982, the government changed the title *prefect* to *commissioner*.

The 1981 elections resulted in a sharp decline in the number of parliamentary seats held by Communists. But the Communists had supported Mitterrand in the presidential race. He appointed Communists to four minor posts in the 44-member cabinet, marking the first Communist participation in the cabinet since 1947. In 1984, the Communists resigned after disagreements with the government over economic policies.

The Socialists lost their parliamentary majority in the 1986 elections. Conservatives gained control of parliament. Mitterrand remained president, but he named Jacques Chirac, a conservative, as prime minister. Chirac gained much influence in the government. In the 1988 elections, Mitterrand waged a successful campaign against Chirac and won a second term as president. Shortly after his election, Mitterrand dissolved the National Assembly. In new legislative elections, the Socialists and their allies won a slight majority. As a result, in 1988, Mitterrand appointed Michel Rocard, a Socialist to replace Jacques Chirac as prime minister. Rocard's government followed social and economic policies quite similar to those favoured by moderates and conservatives. Rocard resigned in 1991 and was replaced by the former European affairs minister, Edith Cresson. She became France's first woman prime minister. However, she was an unpopular choice, and she resigned in April 1992. She was succeeded by Pierre Bérégovoy.

The general election held in March 1993 resulted in an overwhelming victory for the conservatives. The Gaullist RPR party and the centre-right Union for French Democracy (UDF) together took 484 seats in the 577-seat French parliament. Socialist representation was reduced to 70 seats. Former finance minister Edouard Balladur, a Gaullist, succeeded Beregovoy as prime minister. Mitterrand's term of office ended in 1995, and RPR candidate Jacques Chirac was elected president. Chirac appointed Alain Juppe, of the RPR, prime minister.

Like all modern countries, France has economic and social problems that remain unsolved. Large numbers of immigrants from Africa and southern Europe live in crowded city slums and in large apartment blocks on the outskirts of cities. Elderly people on fixed incomes, and farmers whose farms are too small to modernize, barely manage to make ends meet in times of inflation. Unemployment is a major problem. Young people suffer from unemployment more than any other group.

Despite its economic problems, however, France's overall standard of living is higher today than ever before. Most French people own such material goods as cars, refrigerators, telephones, and washing machines. Social security laws give workers some protection against unemployment, illness, and old age.

France ranks among the world leaders in total industrial production and in the export of agricultural products. Nuclear power plants are being built to relieve France from dependence on imported fuels. The army has been modernized, and France has its own nuclear weapons.

Related articles in *World Book* include:

Political and military leaders

See the table *Kings and emperors of France* with this article. Other biographies include:

Catherine de Médicis
Charles Martel
Chateaubriand, François R. de
Claudel, Paul
Clemenceau, Georges
Colbert, Jean B.
Condorcet, Marquis de
Corday, Charlotte
Daladier, Édouard
Danton, Georges J.
De Gaulle, Charles A. J. M.
Eugénie Marie de Montijo
Foch, Ferdinand
Giscard d'Estaing, Valéry
Lafayette, Marquis de
Lamartine, Alphonse
Laval, Pierre
Marat, Jean P.
Mazarin, Jules Cardinal
Mirabeau, Comte de
Mitterrand, François Maurice
Montcalm, Marquis de
Murat, Joachim
Ney, Michel
Pétain, Henri P.
Poincaré, Raymond
Richelieu, Cardinal
Robespierre
Rochambeau, Comte de
Roland de la Platière, Marie
Sieyès, Emmanuel J.
Talleyrand
Thiers, Louis A.
Tocqueville, Alexis de

Cities and towns

Amiens
Avignon
Bordeaux
Brest
Calais
Cannes
Carcassonne
Chartres
Cherbourg
Dunkerque
Fontainebleau
Grenoble
La Rochelle
Le Havre
Le Mans
Lille
Lourdes
Lyon
Marseille
Nancy
Nantes
Nice
Orléans
Paris
Reims
Rouen
Strasbourg
Toulon
Toulouse
Tours
Versailles
Vichy

History

Agincourt, Battle of
Austerlitz, Battle of
Bastille
Bourbon
Continental System
Crécy, Battle of
Crimean War
Crusades
Dauphin
Estates-General
Feudalism
Franco-Prussian War
Franks
French Revolution
Huguenots
Hundred Years' War
July Revolution
Mississippi Scheme
New France
Poitiers, Battle of
Reformation
Renaissance
Revolution of 1848
Succession wars
Waldenses
World War I
World War II
Zouaves

Overseas possessions

French Guiana
French Polynesia
French Southern and Antarctic Territories
Guadeloupe
Martinique
New Caledonia
Reunion
Saint-Pierre and Miquelon

Physical features

Aisne River
Ardennes Mountains and Forest
Bay of Biscay
Corsica
Dover, Strait of
English Channel
Loire River
Marne River
Mont Blanc
Pyrenees
Rhône River
Saône River
Seine River
Somme River

Regions

Alsace-Lorraine
Brittany
Burgundy
Flanders
Gascony
Normandy
Riviera

Other related articles

Architecture
Army (The French Army)
Basques
Bastille Day
Bibliothèque Nationale
Christmas (In France)
Classical music
Code Napoléon
Cycling (Road races)
Democracy (French contributions to democracy)
Denis, Saint
Doll (History)
École des Beaux-Arts
Eiffel Tower
Film Industry
Fleur-de-lis
Foreign Legion
French Academy
French language
French literature
Furniture
Institute of France
Louvre
Maginot Line
Marseillaise
Navy (The world's major navies)
Normans
Painting
Paris, University of
Premier
Salic law
Sculpture
Sorbonne
Statue of Liberty
Theatre (France)
Tuileries
Wine (Where wine comes from)

Outline

I. **Government**
   A. National government
   B. Local government
   C. Politics
   D. Courts
   E. Armed forces
II. **People**
   A. Population
   B. Ancestry
   C. Language
III. **Way of life**
   A. City life
   B. Rural life
   C. Food and drink
   D. Recreation
   E. Holidays
   F. Religion
   G. Education
   H. Museums and libraries
IV. **Arts**
   A. The Middle Ages
   B. The Renaissance
   C. Baroque and rococo art
   D. French classical art
   E. The Age of Reason
   F. Romanticism
   G. Realism and naturalism
   H. Impressionism
   I. The 1900's
V. **The land**
VI. **Climate**
VII. **Economy**
   A. Natural resources
   B. Service industries
   C. Manufacturing
   D. Agriculture
   E. Forestry
   F. Mining
   G. Fishing
   H. Energy sources
   I. Foreign trade
   J. Transportation
   K. Communication
VIII. **History**

Questions

What major changes in French government were made by Charles de Gaulle?
How did France get its name?
What is the principal religion of France?
How did the Romans influence French ways of life?
What is France's chief crop? What is France's chief mineral deposit?
Who seized control after the French Revolution?
What are French secondary schools called?
What led to De Gaulle's return to power in 1958?
What is France's cultural and economic centre?
How does France rank in foreign trade?

France, Anatole (1844-1924), was the pen name of Jacques Anatole François Thibault, a French novelist and critic. He won the 1921 Nobel Prize for literature.

France was born in Paris, the son of a successful bookseller. His childhood was filled with the magic of literature. In his autobiography, *My Friend's Book* (1885), France recalled the pleasures of those years and the mental stimulation he received from living in Paris, with its libraries and bookshops.

France's first successful novel was *The Crime of Sylvester Bonnard* (1881). Beginning in 1886, he wrote a literary column for the newspaper *Le Temps*. His clear and elegant style, the subtlety of his observation, and his disinterested rejection of extreme causes gained him the reputation of being a friendly, easy-going man. France's novel *Thaïs* (1890) seemed to symbolize his ideals of pleasure and wisdom.

The famous Dreyfus affair, which shook the nation, led France to write about political and social issues (see **Dreyfus, Alfred**). His novels of the 1900's reflect his part in the struggle for social justice that took place in the country. He began to ridicule society and its institutions in *Penguin Island* (1908), his most famous novel, and in *The Gods are Athirst* (1912) and *The Revolt of the Angels* (1914). The irony of these novels has been compared to that of the works of Voltaire.

Francesca, Piero della. See **Piero della Francesca.**

Franchise is a type of business agreement. Under such an agreement, a company, individual, or governmental unit grants another company or individual the right to sell certain products or services for a particular period at a specific location. The right itself is also called a franchise. There are two main types of franchise agreements—private and public.

Private franchises are a popular way to conduct business. Franchise units include such business operations as Holiday Inn, Kentucky Fried Chicken, Macdonalds, and Pizza Hut.

Under a franchise agreement, a *franchisee* (buyer) pays a fee to a *franchisor* (seller) to obtain the franchise. The franchisee may also pay a percentage of the firm's sales to the franchisor. In return, the franchisor provides the franchisee with such services as personnel training, financial assistance, and advertising. In addition, the franchisor often allows the franchisee to use a well-known trade name. This feature may be extremely valuable to the franchisee. For example, suppose a family is travelling through an unfamiliar town at lunchtime. The family sees just ahead three possible places to stop for a meal, one of which bears the name of a well-known franchise. Although people who have eaten at all three know that the food they serve is equally good, the travelling family will probably stop at the well-known franchise unit. They are likely to recognize its name because they have probably eaten at another restaurant of the same name in the past.

Public franchises are usually between public utilities and a local government unit. For example, suppose a local authority and a refuse collection company have reached an agreement about refuse collection in the area. Under a typical agreement of this nature, the local authority would grant the company the right to be the only refuse collection company in the area. In return, the company would have to serve all public needs for this service and to have its fees approved by a local authority.

See also **Chain store** (Franchise chain stores); **Public utility; Restaurant** (Chains and franchises).

Francis was the name of two kings who ruled France in the 1500's.

Francis I (1494-1547) became king in 1515, succeeding Louis XII, who was both his cousin and his father-in-law. He was intelligent, fond of pleasure, and devoted to the arts. He was also ambitious, inconstant, and somewhat dishonest. He began his reign brilliantly with the great victory of Marignano in 1515. This victory gave him a foothold in northern Italy.

It soon became clear, however, that the interests and ambitions of France clashed with those of the Holy Roman Empire, which included Spain and Germany. Francis and the Holy Roman Emperor Charles V carried on a bitter struggle for years (see **Charles [V] Holy Roman emperor**). Francis was captured and imprisoned in 1525, in another Italian campaign. He won his freedom in 1526 by making false promises. The last war between Francis I and Charles V ended in 1544 without having made great changes. Francis had shown himself greedy for power and indifferent about how he obtained it.

Francis persecuted the Protestants, but not so severely as some of his successors had done. Possibly the king would have been more savage against them if he had not given most of his attention to other affairs. He enjoyed beautiful surroundings, took an interest in new art and literature, and spent money lavishly. Such activities gave him a reputation as a patron of the Renaissance.

Francis II (1544-1560), grandson of Francis I, became king in 1559, but died the next year. Mary, Queen of Scots, was his wife. During his reign, the long, bitter rivalry between the noble houses of Guise and Bourbon began, which cost France so much during the religious wars between Catholics and Huguenots.

See also **Catherine de Médicis; France** (A period of wars); **Huguenots; Mary, Queen of Scots.**

Francis II (1768-1835) was the last Holy Roman emperor. He also reigned as Emperor Francis I of Austria. He strongly opposed revolutionary movements generated in Europe by the French Revolution (1789-1799).

Francis was born in Florence, Italy, and belonged to the Habsburg (or Hapsburg) family. He succeeded his father, Leopold II, as ruler of Austria in 1792 and was elected Holy Roman emperor that same year. In 1804, Francis adopted the additional title of emperor of Austria. By 1806, Emperor Napoleon I of France had forced Francis to resign as Holy Roman emperor, and the Holy Roman Empire ended. After 1809, Francis allowed his shrewd foreign minister, Prince von Metternich, to direct Austria's foreign affairs. Under Metternich's guidance, Austria in time joined Great Britain, Prussia, and Russia to fight Napoleon. The united European powers defeated Napoleon in 1814 and 1815.

As emperor of Austria, Francis blocked all efforts aimed at even modest political reform. These efforts included growing demands for local self-government by Bohemians, Croatians, Hungarians, Italians, and other groups. At the end of his reign, Francis urged his successor to "Rule and change nothing."

See also **Aix-la-Chapelle, Congress of; Holy Alliance; Marie Louise; Metternich.**

Francis, Dick (1920-) is a British author of mystery novels, most with horse-racing backgrounds. Francis' books feature ordinary men who are called upon to be heroes. They are not detectives, but are cast into roles in which they must solve mysteries. Francis' thrillers have won acclaim for their crisp, clear prose and expert handling of character and suspense.

Francis was born near Tenby, Wales. He was a leading English steeplechase jockey from 1948 to 1957. He was racing correspondent for the London *Sunday Express* from 1957 to 1973. His first mystery novel, *Dead Cert*, was published in 1962. Francis' later mysteries have explored such subjects as photography (*Reflex*, 1981), banking (*Banker*, 1983), the distillery business (*Proof*, 1985), and gems (*Straight*, 1989). His other novels include *Nerve* (1964), *Rat Race* (1971), *Twice Shy* (1982), and *Comeback* (1991). *The Sport of Queens* (1957) is an autobiographical account of Francis' career in horse racing.

Francis de Sales, Saint (1567-1622), was a French nobleman. He was educated at the College of Clermont in Paris. There he became so devoted to the Blessed Virgin Mary that he took a vow of chastity and dedicated himself to her service. After becoming a doctor of law in Padua, Italy, he entered the priesthood in 1593. In 1602 he became bishop of Geneva in Switzerland. He and Saint Jane de Chantal established the Visitation Order for the purposes of teaching and caring for the sick. Francis wrote many spiritual books, the most popular of which is *An Introduction to the Devout Life*. He was born in Thorens, in Savoy, France. His feast day is January 29.

Francis Ferdinand, archduke of Austria. See **World War I** (The assassination of an archduke); **Austria** (Austria-Hungary).

Francis Joseph (1830-1916), also spelled *Franz Josef*, was the aged ruler of the dual monarchy of Austria-Hungary at the beginning of World War I. Francis Joseph ruled as emperor of Austria for 68 years. His popularity, as well as military force, held the widely different elements of the dual monarchy together. When his heir and nephew, Archduke Francis Ferdinand, was assassinated in 1914, Francis Joseph declared war on Serbia. This led to World War I (see **Serbia; World War I**).

Francis Joseph became Emperor of Austria in 1848, a year of national revolutions. He was a member of the ancient ruling family of Habsburg (or Hapsburg; see **Habsburg, House of**). During his long reign Austria prospered, although it suffered several military defeats. In the war against Sardinia and France in 1859, Austria lost the province of Lombardy (see **Sardinia, Kingdom of**). Prussia defeated Austria and three smaller German states in the Seven Weeks' War of 1866. As a result, Austria lost much of its influence in Germany (see **Seven Weeks' War**). Francis Joseph then adopted more liberal internal policies, allowing the Hungarians equal rights. This brought about the Austro-Hungarian empire, and Francis Joseph took the additional title of king of Hungary in 1867 (see **Austria-Hungary**).

Francis Joseph's only son, Rudolph, killed himself in 1889. An Italian anarchist killed Francis Joseph's wife Elizabeth. A nephew, Charles I, succeeded him as emperor (see **Charles I**).

Francis of Assisi, Saint (1181?-1226), founded the Franciscan religious order of the Roman Catholic

St. Francis in Ecstasy (about 1480), a tempera and oil painting on a [illegible]

Saint Francis of Assisi was one of the most popular saints of the Middle Ages. This painting by the Italian artist Giovanni Bellini shows Francis about to receive the *stigmata*—wounds resembling those that Jesus received at the Crucifixion. The gentle animals and peaceful landscape symbolize the saint's love of nature and all living things.

Church. His simple life of poverty inspired many people during the Middle Ages. Today, many people admire Francis because of his love of peace and his respect for all living creatures.

Francis, the son of a prosperous textile merchant, was born in Assisi, Italy. As a young man, he took an active part in the city's commercial, political, and social life. Francis was captured while fighting in a war between Assisi and the nearby city of Perugia. He spent most of 1202 and 1203 in an enemy prison. The suffering he saw during the war caused him to think about the meaning and purpose of his life.

In 1205, after seeing a vision of Jesus Christ, Francis changed his way of life. He disowned his father, rejected his inheritance, and began to devote his life to rebuilding churches and serving the poor. Francis adopted absolute poverty as his ideal. He attempted to pattern his own life after the life of Christ by preaching the Gospel and healing the sick. Soon, Francis started to attract followers.

In 1209, Francis founded the Franciscan order. Although many of his followers became priests, Francis remained a layman. See **Franciscans.**

In 1212, while travelling to Syria to convert the Muslims, Francis was shipwrecked on the coast of Croatia. He tried to go to Morocco as a missionary but became ill in Spain and could not continue. In 1219, Francis accompanied the crusaders to Egypt. There, he tried to convert the sultan but failed.

Francis returned to Italy in 1220. He continued to preach but let others administer the Franciscans. In 1224, while Francis prayed on Mount Alvernia, near Florence, the *stigmata* appeared on his body. The stigmata are five wounds resembling those suffered by Jesus on His hands, feet, and side during the Crucifixion. Two years later, Francis died near Assisi in the Portiuncula chapel, his favourite church and the first headquarters of the Franciscans. Francis was *canonized* (declared a saint) in 1228. His feast day is celebrated on October 4.

Francis expressed his religious ideals in poems as well as through his ministry. In "Canticle of the Sun," he showed his love for all living things. His poems also contributed to the development of Italian literature. About 100 years after Francis' death, a Franciscan collected stories about the saint and his companions in *The Little Flowers of Saint Francis.*

Francis turbine. See **Turbine** (Water turbines).

Francis Xavier. See **Xavier, Saint Francis.**

Franciscans are members of a variety of Roman Catholic religious orders that take their inspiration and *rule* (programme of life) from Saint Francis of Assisi. In 1209, Francis founded the Order of Friars Minor to reform the church around the spirit of poverty based on the Gospels. Between 1212 and 1214, Francis and his friend Saint Clare founded an order for women called the Second Order of St. Francis or the Poor Clares.

The expansion of the Franciscans led to an overly complex organization and a consequent need to revise the rule. A split occurred between the Spirituals or *zelanti* and the main body, later called the Conventuals. The Spirituals wanted strict observance of Francis' original rule. The Conventuals advocated moderation. Pope John XXII settled the dispute in favour of the Conventuals in 1317. In 1415, a reform movement within the Conventuals resulted in the formation of another group called the Observants. In 1897, Pope Leo XIII issued a unification decree that produced today's three independent families of Franciscan orders for men—the Friars Minor, Friars Minor Conventuals, and Friars Minor Capuchins.

The early Franciscans devoted themselves to preaching and to caring for the spiritual needs of the people. But the order soon branched out into educational, missionary, and social work.

See also **California** (History); **Capuchins; Francis of Assisi, Saint; Friar.**

Francium is a radioactive element produced in certain nuclear reactions. Its chemical symbol is Fr. It is the heaviest member of the group of elements called the *alkali metals.* The group also includes lithium, sodium, potassium, rubidium, and caesium. Like the other alkali metals, francium takes the form of singly charged positive ions in its compounds. Its chemical properties closely resemble those of caesium. See **Alkali; Caesium.**

The most stable isotope of francium has a half-life of 21 minutes (see **Radioactivity** [Half-life]). Because of this great instability, scientists have not been able to produce weighable quantities of the element.

The French scientist Marguerite Perey discovered francium in 1939 as a product of the radioactive decay of actinium. It was formerly known as *virginium.* Francium has an atomic number of 87.

Franck, César (1822-1890), was a French composer, organist, and teacher. His compositions are a synthesis of the strict Viennese forms of sonata, symphony, and quartet and the late romantic harmonies of composers Franz Liszt and Richard Wagner.

Franck wrote several oratorios and operas, but he achieved his greatest success with his instrumental works. The Symphony in D minor (1889) is his most frequently performed piece, followed by the Sonata in A major (1887) for violin and piano. Franck's other major compositions include the Quintet in F minor (1880) for piano and strings, the String Quartet in D major (1890), the complex *Symphonic Variations* (1886) for piano and orchestra, and the *Prelude, Chorale, and Fugue* (1885) for piano.

César Auguste Jean Guillaume Hubert Franck was born in Liège, Belgium, and moved to Paris with his family in 1835. He was the organist at the Basilica of Ste.-Clotilde from 1858 until his death. Franck gave many acclaimed organ concerts following services at the church. His *Six Pieces* (1868) for organ emerged from those concerts. Franck taught organ at the Paris Conservatory from 1872 until his death, exerting a strong influence on such composers as Paul Dukas, Vincent d'Indy, and Henri Duparc.

Franck, James. See **Nobel Prizes** (Nobel Prizes for physics—1925).

Franco, Francisco (1892-1975), was dictator of Spain from 1939 until his death in 1975. He came to power at the end of the Spanish Civil War. During that war, he led the rebel Nationalist Army to victory over the *Loyalist* (Republican) forces. After the war ended in 1939, Franco held complete control of Spain. His regime was similar to a Fascist dictatorship. He carried out the functions of chief of state, prime minister, commander in chief, and


Francisco Franco

leader of the Falange, the only political party permitted (see **Falange Española**). He adopted the title of *El Caudillo* (The Leader).

His early life. Franco was born Francisco Franco Bahamonde in El Ferrol del Caudillo, in the province of La Coruña, Spain. His father was a naval officer. Young Franco was trained as an army officer at the Infantry Academy of Toledo. Between 1912 and 1927, he held important command posts in Spanish Morocco. He was made a general at the age of 34.

In 1931, Spain became a republic. During the next five years, disputes involving Spanish political groups became increasingly severe. At first, Franco avoided becoming involved in the disputes. But when the moderate conservatives won the election of 1933, Franco became identified with them. In 1934, Franco helped put down a revolt by *leftists,* who wanted sweeping changes in Spain's way of life. In 1935, he became army chief of staff. The following year, the leftists won the election and sent Franco to a post in the Canary Islands.

Military leaders plotted to overthrow the leftist government in 1936. The revolt began in July 1936 and it started a total civil war. The rebel generals named Franco commander in chief and dictator. Franco's forces, called Nationalists, received strong support from Italy and Germany. On April 1, 1939, after 32 months of bitter fighting, the Nationalists gained complete victory. Franco then became dictator without opposition.

As dictator, Franco kept Spain officially neutral during World War II. But he sent "volunteers" to help Germany fight the Soviet Union. After the war, the victorious Allies would have little to do with Spain because of Franco's pro-Fascist policies.

The Western powers became more friendly toward Franco during the Cold War with the Soviet Union, because he was against Communism. In 1953, Franco signed an agreement with the United States. He permitted the United States to build air and naval bases in Spain in exchange for economic and military aid. This aid helped bring about industrial expansion. Spain's living standard rose dramatically during the 1960's.

Franco declared, in 1947, that Spain would be ruled by a king after he left office. In 1969, Franco named Prince Juan Carlos to be king and head of state after Franco's death or retirement. Juan Carlos is the grandson of King Alfonso XIII, who left Spain in 1931. Franco died in November 1975, and Juan Carlos became king (see **Juan Carlos I**).

See also **Spain** (Government; History).

Franco-Prussian War began in 1870 as a result of a dispute between France and Prussia, a German state. All the other German states joined Prussia, and the conflict became one between France and Germany.

Events leading up to the war. Prussia had defeated Austria in the Seven Weeks' War and had replaced it as the leading German power. Emperor Napoleon III of France allowed himself to be influenced by patriots who wanted to humiliate Prussia. Otto von Bismarck, Prussia's prime minister, was equally anxious for a struggle. Bismarck hoped to strengthen the unity of the German states by having them fight a war against France.

An excuse for war was easily found. Prince Leopold of Hohenzollern-Sigmaringen, a Roman Catholic relative of the Prussian king, had been offered the Spanish crown. The French felt that if Leopold ruled Spain, the Hohenzollern family would become too powerful. Leopold's father refused the crown on his behalf, but France insisted on a Prussian guarantee that Leopold would be forbidden from ever accepting the Spanish throne.

Count Benedetti, the French ambassador, presented this demand to Wilhelm I of Prussia at Ems, in Prussia. Wilhelm received Benedetti politely, but refused the French demand. He then sent a telegram to Bismarck telling him what had happened. Bismarck condensed this "Ems dispatch" in such a way that it aroused great fury when it was published in France on July 14, 1870. The French declared war on July 19.

Progress of the war. Both countries entered the struggle with enthusiasm. General Helmuth Karl von Moltke, head of the Prussian Army, had made careful preparations for war with France. The French were largely unprepared.

The Germans defeated the French at Wissembourg, Woerth, and Spicheren, and inflicted severe losses. The French armies under Marshal MacMahon and Marshal Bazaine were separated and kept apart by the Germans. Bazaine was surrounded at Metz. MacMahon, who had been ordered to march to the relief of Bazaine, met the Germans in a great battle near Sedan. The French were overwhelmed. MacMahon's army surrendered, and the Emperor Napoleon III was taken prisoner. Bazaine later surrendered at Metz.

End of the war. When the news of the defeat at Sedan reached Paris, the French deposed Napoleon and prepared to defend the city. The army and the citizens of Paris fought bravely, but they had to yield the city to the Germans early in 1871. The war ended with the Treaty of Frankfurt, which was signed on May 10, 1871. The treaty provided that France would give most of Alsace and part of Lorraine to Germany, pay Germany the equivalent of one billion U.S. dollars, and support a German army of occupation until the sum was paid. Germany expected the huge debt to handicap France for many years. But the French miraculously paid it off in less than three years. The French government, with the financial help of the French people, secured loans that enabled it to pay off the debt.

Results. The Franco-Prussian War abolished the North German Confederation and created a new German Empire. It helped set the stage for World War I by increasing French and German hostility.

Related articles in *World Book* include:

Alsace-Lorraine
Balloon (Balloons in war)
Bismarck, Otto von
Germany (History)
Hohenzollern
Moltke, Helmuth Karl von
Napoleon III
Prussia
Seven Weeks' War
Thiers, Louis Adolphe
Wilhelm (I) of Germany

Frank. See Franks.

Frank, Anne (1929-1945), a German-Jewish girl, wrote a vivid, tender diary while hiding from the Nazis dur-

ing World War II. Anne was born in Frankfurt. She and her family moved to the Netherlands in 1933 after the Nazis began to persecute Jews. In 1942, during the Nazi occupation of the Netherlands, the family hid in a secret annexe behind the Amsterdam office of her father's business. Anne recorded her experiences in a diary. Two years later, the family was betrayed to the Nazis and arrested. Anne died in the Nazi concentration camp at Belsen, Germany. Her diary was published in 1947, and later was made into a play and a film, both called *The Diary of Anne Frank*.

Anne Frank

Frank, Ilya M. See **Nobel Prizes** (Nobel Prizes for physics).

Frankenstein is a famous horror novel written by the English author Mary Shelley. The novel was published in 1818 under the title *Frankenstein, or the Modern Prometheus*. It tells the story of Victor Frankenstein, a scientist who tries to create a living being for the good of humanity but instead produces a monster.

Frankenstein creates his monster by assembling parts of dead bodies and activating the creature with electricity. The monster, which has no name in the book, is actually a gentle, intelligent creature. However, everyone fears and mistreats him because of his hideous appearance. Frankenstein rejects the monster and refuses to create a mate for him. The monster's terrible loneliness drives him to seek revenge by murdering Frankenstein's wife, brother, and best friend. Frankenstein dies while trying to track down and kill the monster, who disappears into the Arctic at the end of the novel.

Frankenstein is a famous horror novel by Mary Shelley. Frankenstein's monster appears in this scene from the film *The Bride of Frankenstein* (1935).

Many films have been based on the character of Frankenstein's monster. Most are simply tales of horror and have little to do with the serious themes of Shelley's novel. These themes include the possible dangers involved in scientific experimentation with life and the suffering caused by judging people by their appearance.

See also **Shelley, Mary W.**

Frankenthaler, Helen (1928-), an American artist, is a leading abstract expressionist painter. Frankenthaler's works illustrate the physical process involved in creating a painting, rather than communicating an idea through the subject. Colours run into one another in her paintings, and forms overlap visibly. Some areas in her works remain unpainted, so the canvas is part of the painting.

Frankenthaler developed a painting technique called *soak-stain*. This method involves pouring thin layers of paint on raw canvas. The effect eliminates texture and emphasizes the flatness of the canvas surface. Frankenthaler rejected brushwork texture and allowed the colour and texture of the paint itself to become major elements of the painting. Her painting *Pre-Dawn* is reproduced in the **Painting** article. Frankenthaler was born in New York City.

Frankfurt (pop. 595,348) is the transportation hub of Germany. The city's full name is Frankfurt am Main. It stands on the banks of the Main River, about 160 kilometres southeast of Cologne. For location, see **Germany** (political map). A network of railways and *autobahns* (motorways) links the city with all of western Europe. Frankfurt airport covers a larger area than any other airport in Europe. A river and canal system links the city with the North Sea. Frankfurt has three harbour areas, and ranks third among the inland ports of Germany.

The city is a world centre of commerce and banking. The Rothschild family opened its first bank there in 1798 (see **Rothschild**). Frankfurt holds two great trade fairs every year. The fair held in September began in 1240 and the February fair started in 1330. The city also holds many specialized fairs, including one for the book trade. Factories in Frankfurt produce chemicals, machinery, and electrical equipment.

Frankfurt is an important centre of German intellectual and cultural life. The city is the birthplace of the German writer Johann Wolfgang von Goethe, whose home is now a museum. Frankfurt's attractions include the Römer town hall, a building that dates from the 1400's. The building contains the *Kaisersaal*, the meeting room at one time of the German emperors and princes. Also in the city is the Paulskirche, a church where leaders of the unsuccessful Revolution of 1848 met to draft a German national constitution.

Frankfurt's geographical position made it important from the time of the Roman Empire. The shallow ford in the Main River provided the easiest north-south river crossing in all Germany. The Franks forded the river in early times, and the city's name means *ford of the Franks* (see **Franks**). Merchants travelling between Mediterranean countries and northern Europe naturally passed through Frankfurt. In about A.D. 500, the Franks seized a

Roman fort at the crossing and founded a settlement. Allied bombers levelled nearly half of Frankfurt during World War II (1939-1945), but the city was rebuilt after the war.

Frankfurter. See **Sausage**.

Frankincense is a fragrant gum resin obtained from certain trees that grow in Africa and Asia. It is also called *olibanum*. Since ancient times, frankincense has been burned as an incense during religious services. The Bible says that one of the wise men brought Jesus a gift of frankincense (Matt. 2).

Frankincense is the hardened resin from the bark of trees of the genus *Boswellia*. The resin hardens into pale-coloured drops called *tears*. These tears are used as incense in religious services. Perfumers dissolve the natural resin in alcohol to get a product called *olibanum absolute*. When steam is passed through olibanum absolute, it yields an oil perfumers call *essential oil*. This essential oil is added to perfumes to give a long-lasting, spicy fragrance.

Frankland, Sir Edward (1825-1899), was an English chemist. His researches covered a wide field. With Alexander Crum Brown, Frankland worked on structural formulae. With Joseph Lockyer, in 1868, he discovered helium in the sun's atmosphere. With Hermann Kolbe, he worked on the theory of valency (see **Valency**). Frankland was the first person to make the organo-metallic compounds zinc methyl and zinc ethyl. He also demonstrated the amounts of carbon and nitrogen in natural water. Frankland was born at Churchtown, in Lancashire, England.

Franklin, Aretha (1942-), an American rhythm and blues singer, ranks among the best-selling female artists in the history of recorded music. Franklin is popularly known as the "Queen of Soul." Her 1967 recording of "Respect" became an inspirational anthem for the American civil rights movement and a symbol of black pride.

Franklin was born in Memphis and raised in Detroit. She began her singing career at the age of 12 in the Detroit church of her father, C. L. Franklin, a noted preacher and gospel singer. She later transferred the passion and intensity of her gospel singing to popular songs. Most of Franklin's recordings also feature her piano playing.

Franklin's period of greatest popularity came in the late 1960's. In 1967 alone she had 5 top 10 hit records: "I Never Loved a Man (The Way I Love You)," "Respect," "Baby, I Love You," "(You Make Me Feel Like) A Natural Woman," and "Chain of Fools." Franklin recorded gospel music on such albums as *Amazing Grace* (1972) and *One Lord, One Faith, One Baptism* (1987).

Franklin, Benjamin (1706-1790), was an American writer, publisher, public servant, scientist, philanthropist, and diplomat.

Childhood. Benjamin Franklin was born in Boston, Massachusetts. At the age of 12, Benjamin was apprenticed to his brother James, a printer. He learned printing quickly. But at 17, Franklin ran away to Philadelphia.

Printer and publisher. In the 1720's, Franklin worked for various printers in Philadelphia. From 1729 to 1766, he was publisher of *The Pennsylvania Gazette*.

Franklin achieved even greater success with *Poor Richard's Almanac*. He wrote and published the almanac for every year from 1733 to 1758.

Civic leader. Franklin became Philadelphia's postmaster in 1737 and greatly improved the postal service. He helped establish the first subscription library in the American Colonies. He raised money to help build America's first city hospital, the Pennsylvania Hospital. He also helped establish the American Philosophical Society and helped found an academy that grew into the University of Pennsylvania.

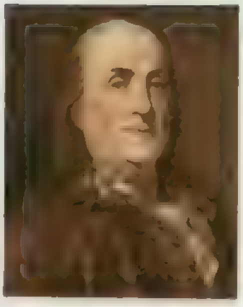
Scientist. Franklin was one of the first people to experiment with electricity. His kite experiment in 1752 proved that lightning is electricity. Later, Franklin invented the lightning conductor. See **Electricity** (History).

Franklin was the first scientist to study the movement of the Gulf Stream in the Atlantic Ocean. He charted its course and recorded its temperature, speed, and depth.

Frankfurt is a world centre of commerce and banking and an important centre of German intellectual and cultural life. Frankfurt's industries include chemicals, machinery, and electrical equipment.

Franklin showed how to improve acid soil by using lime. He favoured daylight-saving time in summer.

Public servant. In the spring of 1754, war broke out between the British and French in America. Franklin felt that the colonies had to unite for self-defence. Franklin presented a Plan of Union at a conference of seven colonies in New York. It tried unsuccessfully to bring the American Colonies together in "one general government." It contained ideas that were later included in the Constitution of the United States.



Benjamin Franklin

Delegate in London. In 1757, the Pennsylvania legislature sent Franklin to London to speak for the colony in a tax dispute. He remained in Britain for most of the next 18 years as a sort of unofficial ambassador.

Organizing the new nation. Franklin returned to Philadelphia in 1775, about two weeks after the American Revolution had begun. The people of Philadelphia chose him to serve in the Second Continental Congress. Franklin helped draft the Declaration of Independence in 1776, and was one of its signatories.

Diplomat in France. Shortly after the Declaration of Independence was adopted in 1776, the Continental Congress appointed Franklin as one of three commissioners sent to represent the United States in France.

The French agreed to a treaty of alliance. The pact was signed on Feb. 6, 1778. Many historians believe that without French aid the Americans could not have won their independence. In 1778, Franklin was appointed minister to France. He helped draft the Treaty of Paris of 1783, which ended the American Revolution.

Later years. Franklin returned to Philadelphia in 1785. In 1787, Pennsylvania sent Franklin to the convention that was to draft the Constitution of the United States. Franklin, at 81, was the oldest delegate.

Franklin rejoiced in George Washington's inauguration as the first president of the United States. In 1787, he was elected president of the first antislavery society in America. Franklin died in 1790, at the age of 84.

Franklin, Sir John (1786-1847), pioneered English exploration in the Arctic area. He lost his life during an expedition to find a water route across North America, called the Northwest Passage.

Franklin was born in Lincolnshire, England, and joined the British Navy at the age of 15. He was a midshipman on Matthew Flinders' voyage around Australia in 1803. In 1819, Franklin explored the mouth of the Coppermine River while leading his first Arctic expedition. He led his second expedition to the Arctic in 1825 and 1826.

In 1845, Franklin led the best-equipped expedition to enter the Arctic up to that time. He discovered a Northwest Passage, but he and his crew died during the expedition. When no one returned from the voyage, Lady Franklin sponsored five expeditions to search for her husband. A full exploration of the Arctic region resulted. A search party led by Sir Robert McClure crossed the Northwest Passage during an expedition from 1850 to 1854. Later, explorers found evidence of Franklin's party and reconstructed his voyage.

See also **Northwest Passage**.

Franklin, Miles (1879-1954), an Australian author, gained a major reputation as a novelist of the countryside. Her books include *My Brilliant Career*, a study of the frustrations of youth in a pioneering society. She also wrote novels under the pen name Brent of Bin Bin, including *Up the Country* and *Back to Bool Bool*. Her full name was Stella Maria Sarah Miles Franklin.

Franklin was born at Talbingo, in New South Wales. Her will provided for the annual Miles Franklin Literary Award.

Franklin, Rosalind (1920-1958), was a British chemist and molecular biologist. She made important X-ray studies of *deoxyribonucleic acid*, commonly called *DNA*, which transmits genetic information from one generation to the next (see **Cell**). Franklin's work contributed greatly to the construction in 1953 of a model of the structure of DNA. This model was built by the biologists James Watson of the United States and Francis Crick of the United Kingdom. Franklin's research also helped verify the accuracy of the model.

Franklin made other important contributions to chemistry and molecular biology through her use of X-ray diffraction techniques (see **X rays** [In scientific research]). Her structural analysis of coals and charcoals promoted a better understanding of their properties. She also determined the complex structure of the tobacco mosaic virus, which attacks tobacco plants.

Rosalind Elsie Franklin was born in London and graduated from Cambridge University in 1941. She died of cancer at the age of 37.

Franklin River is a river in southwestern Tasmania, Australia. Several caves in the area contain important archaeological evidence that Tasmanian Aborigines lived there about 20,000 years ago, during the last Ice Age. At that time, these people would have been the most southerly human beings on earth. In 1983, the Australian High Court upheld a decision by the federal Labor government to stop the Tasmanian government from building a hydroelectric dam in the area.

Franks were members of a confederation of Germanic peoples that attacked the Roman Empire beginning in

The Frankish kingdom in A.D. 768

the A.D. 200's. The Franks were divided into two branches, the Salians and the Ripuarians. The Salians settled in the Low Countries on the lower Rhine, near the North Sea. The Ripuarians moved into the region around what are now the cities of Trier and Cologne, Germany, on the middle Rhine.

Clovis, a king of the Salian Franks, began a massive invasion of Roman Gaul (now France) in 486. He defeated Gauls, Romans, Visigoths, and others to create a kingdom stretching from east of the Rhine River to the Pyrenees Mountains. Clovis was the first great Germanic ruler to adopt orthodox Christianity, in place of the Christian theological approach called *Arianism* (see **Arianism**). When Clovis died in 511, the Franks, though outnumbered by their Gallo-Roman neighbours 20 to 1, had such a firm hold on Gaul that the region was called France after them.

Frankish history is divided into two periods, the *Merovingian*, from about 481 to 751, and the *Carolingian*, from 751 to 987. Charlemagne, who was king of the Franks from 768 to 814, created a vast empire. In 800, Pope Leo III crowned him emperor of the Romans. After the time of Charlemagne, the Frankish empire began to break up into what later became the kingdoms of France, Germany, and Italy.

See also **Charlemagne; Charles Martel; Clovis I; Feudalism; Merovingian.**

Franz Josef. See **Francis Joseph.**

Franz Josef Land is a group of about 85 islands in the Arctic Ocean, north of Novaya Zemlya. The islands are the most northerly land of the Eastern Hemisphere. They cover about 21,000 square kilometres and are part of Russia. No one lives on most of the islands. The largest islands in the group include Alexandra Land, George Land, Wilczek Land, and Graham Bell Island. In July, the mean temperature is about −12 °C. In winter, the mean temperature is about −30 °C. But gales may force the temperature as low as −46 °C.

An Austro-Hungarian expedition discovered the islands in 1873 and named them after Emperor Franz Josef. The Soviet Union, which was formed under the leadership of Russia in 1922, claimed the islands in 1926. In 1991, the Soviet Union was dissolved.

Fraser, Lady Antonia. See **Longford** (family).

Fraser, Dawn (1937-   ), an Australian swimmer, won three successive gold medals in the women's 100-metre free-style race at the Olympic Games. She won this event in the games held in Melbourne in 1956, in Rome in 1960, and in Tokyo in 1964. She was also the first woman to swim this distance in less than a minute, with a time of 59.5 seconds at Tokyo in 1964. Dawn Fraser was born in Sydney.

Fraser, Malcolm (1930-   ), served as prime minister of Australia from 1975 to 1983. Fraser, then the leader of Australia's Liberal Party, succeeded Labor Party leader Gough Whitlam as prime minister.

Whitlam's government was dismissed in November 1975 by Australia's governor general, Sir John Kerr, after the Senate rejected the national budget. Kerr appointed Fraser as prime minister and instructed him to form a temporary government until an election could be held. The Liberal and National Country (now National) parties combined forces to win the election in December, and Fraser continued as prime minister. Fraser again led the combined Liberal and National Country parties to victory in 1977 and in 1980. As prime minister, Fraser worked to limit government spending, reduce unemployment, and strengthen ties with the United States and the United Kingdom. Inflation and unemployment contributed to the government's unpopularity and helped the Labor Party win the 1983 elections, ending his term as prime minister.

Malcolm Fraser

Fraser was born near Melbourne. His full name is John Malcolm Fraser. Fraser received a master's degree from Oxford University in England. In 1955, he was elected to the Australian House of Representatives. From 1966 to 1971, Fraser served successively as minister for the army, minister for education and science, and minister for defence.

Fraser Island, also called *Great Sandy Island,* is the largest sand island in the world. It lies across Hervey Bay, on the southeastern coast of Queensland, Australia, and shelters the entrance to the port of Maryborough. The island has an area of about 1 550 square kilometres. It has many freshwater lakes. The largest of these lakes, Lake Boemingen, covers more than 200 hectares. Part of the island is a forestry reserve with about 26,300 hectares of commercial forests.

Fraser of the North Cape, Lord (1888-1981), Bruce Austin Fraser, commanded British fleets in World War II. As *comptroller* (controller) of the Navy from 1939 to 1942, he played an important part in building the strength of the Navy early in the war. As commander in chief of the home fleet in 1943 and 1944, he was responsible for sinking the German battle cruiser *Scharnhorst.* Fraser later commanded the eastern and Pacific fleets. He was born in London and was educated at Bradfield College, Berkshire, England.

Frater, William (1890-1974), was a pioneer of post-impressionist painting in Australia. He was strongly influenced by the French painter Paul Cezanne. In 1932, Frater and another Australian painter, George Bell, opened an art school in Melbourne. Their pupils included the Australian painters Sir Russell Drysdale and Sali Herman. Frater was born in Scotland. He later worked as an apprentice to a stained-glass maker. He studied painting at the Glasgow Art School and, later, in Paris and London. He first visited Melbourne in 1910.

Fraud is an intentional untruth or a dishonest scheme used to take deliberate and unfair advantage of another person or group of persons. It includes any means, such as surprise, trickery, or cunning, by which one cheats another.

In some legal systems, fraud is a crime in itself, but in most it is an element present in other crimes. These include obtaining property by deception or embezzlement.

Fraud can also give rise to a civil action for damages. An example is a seller who deliberately claims that an object is in good working order or is new, knowing that it is not. The buyer of such an item could sue to cancel

the contract, and could claim damages on the grounds of misrepresentation.

The *Statute of Frauds,* enacted in England in 1677, required certain common types of contracts, such as those dealing with land and buildings to be in writing. Countries using a common law system have incorporated similar provisions into their laws.

Frazer, Sir James George (1854-1941), a Scottish anthropologist, wrote the famous *Golden Bough.* This book traces the development of the world's religions from their earliest forms. Frazer also wrote *Totemism and Exogamy; Folklore in the Old Testament; Superstition in the Growth of Institutions;* and *Anthologia Anthropologica.* Frazer was born in Glasgow and was educated at Glasgow and Cambridge universities. He taught social anthropology at the University of Liverpool, England.

See also **Mythology** (How myths began).

Freckles. See **Skin** (Skin colour).

Frederick I (1121?-1190), called *Barbarossa* or *Red Beard,* succeeded his uncle Conrad III as king of Germany in 1152. He became Holy Roman emperor in 1155. The German people admired and respected him as a great national hero. In 1180, he defeated his great rival for power in Germany, Henry the Lion, Duke of Saxony and Bavaria. He enforced his authority in Germany and the Slavic borderlands to the east.

He was less successful in a bitter struggle against Pope Alexander III and the Lombard League of North Italian cities. The league defeated Frederick at the Battle of Legnano in 1176. It was in this battle that foot soldiers recorded their first great victory over feudal cavalry. The Lombard cities forced Frederick to grant them self-government in the Peace of Constance in 1183. In 1189, Frederick started on the Third Crusade to the Holy Land. The aim of the crusade was to recapture Jerusalem from Saladin (see **Crusades**). But Frederick drowned the next year while crossing a river. A German legend, however, says that Barbarossa never really died but instead is sleeping beside a huge table in the Kyffhäuser Mountains. When his beard grows completely around the table, the legend says, he will arise and conquer Germany's enemies.

Frederick II (1194-1250), called *Stupor Mundi* (The Amazement of the World), was one of the most brilliant rulers of the Middle Ages. He was an excellent administrator, an able soldier, and a leading scientist of his time. He understood several languages and encouraged the development of poetry and sculpture. His book on falcons is still consulted by experts.

Frederick belonged to the royal Hohenstaufen family (see **Hohenstaufen**). He was the son of the Holy Roman Emperor Henry VI and grandson of Frederick I. Frederick II was crowned German king when he was 2 years old, and king of Italy when he was 4. He became Holy Roman emperor in 1215, and made himself king of Jerusalem in 1229. Frederick governed his Sicilian kingdom well. He established the University of Naples in 1224 and made the University of Salerno the best school of medicine in Europe. Throughout his life, Frederick was in conflict with the popes and the rising towns of Germany and Italy.

Frederick II (1712-1786), the third king of Prussia, became known as Frederick the Great. He started his reign in May 1740 and a few months later invaded Silesia, one of the richest provinces of Maria Theresa of Austria. This attack caused the War of the Austrian Succession. It also led to the Seven Years' War, in which Frederick held off the combined armies of three major powers, Austria, France, and Russia. He kept almost all of Silesia and expanded Prussia further when he joined with Austria and Russia and took a part of Poland (see **Poland** [The partitions]). Frederick built a strong government and army. He encouraged industry and agriculture. He also made Prussia a rival to Austria for control of other German states.

Frederick has been called an "enlightened despot" because he supported the progressive ideas and reforms of the period of history called the *Enlightenment* or *Age of Reason* (see **Age of Reason**). The French writer Voltaire lived at Frederick's court as a guest from 1750 to 1753. The German people remember Frederick as a strong king and a great military hero. Frederick was born in Berlin. He was the son of Frederick William I of Prussia and Princess Sophia Dorothea of Hanover, the sister of King George II of Great Britain.

See also **Frederick William I; Maria Theresa; Prussia** (Frederick the Great); **Seven Years' War; Succession wars.**

Frederick III (1831-1888), the only son of Wilhelm I, became king of Prussia and German emperor in 1888. He died of cancer just three months after he succeeded his father. He believed in parliamentary government and took an important part in political affairs during his father's reign. Bismarck, the chancellor of Imperial Germany, opposed Frederick's liberal views (see **Bismarck, Otto von**). Frederick was born in Potsdam, Germany. He married the Princess Royal Victoria, daughter of Queen Victoria of England. Their oldest son was Wilhelm II (See **Wilhelm** [II]). See also **Prussia.**

Frederick the Great. See **Frederick II** (of Prussia).

Frederick William (1620-1688), often called the Great Elector, ruled the German state of Brandenburg from 1640 to 1688. Brandenburg later became the heart of the powerful Prussian kingdom.

During his rule, Frederick William laid the foundations for the future military greatness of Prussia. He was only 20 years old when he succeeded his father as *elector* (ruler). He ruled Brandenburg during the last eight years of the Thirty Years' War, which brought great ruin to Brandenburg (see **Thirty Years' War**). After the war ended in 1648, Frederick William began to send people to towns that had been deserted. He also won the power to raise and collect taxes and used money to build a standing army. Frederick William fought against both King Louis XIV of France and King Charles XI of Sweden. He defeated Swedish troops in an important battle at Fehrbellin, Germany, in 1675.

Throughout his reign, he devoted much of his time to improving his territory. He encouraged industries, opened canals, and established a postal system. He reorganized the universities of Frankfurt and Königsberg and founded the Royal Library in Berlin. On his death, Frederick William left to his son Frederick III of Brandenburg (later King Frederick I of Prussia) a prosperous state and an enlarged army.

Frederick William I (1688-1740) served as king of Prussia from 1713 until his death. He developed the

most efficient government in Europe and made Prussia a leading military power.

Frederick William I was born in Berlin. He was a member of the Hohenzollern royal family and the son of Frederick I, the first king of Prussia. After becoming king, he established a merit system for hiring and promoting government officials and eliminated corruption in the government by placing spies to observe employees at all levels. Frederick William I also sharply reduced the number of government officials and cut government expenses.

The king used the money saved through his cost-cutting measures to improve the Prussian Army. Frederick William I doubled the size of the army to over 80,000 men and made it the best-trained army in Europe. He was called the "sergeant king" because he spent a great deal of his time with his soldiers. He paid large sums of money to recruit a "Giants Regiment," made up of soldiers more than 180 centimetres tall. Despite the strength of his army, Frederick William I was a timid statesman who kept Prussia out of war for almost his entire reign.

Unlike his father and his son, who later became known as Frederick the Great, Frederick William I had little interest in the arts or education. He publicly ridiculed the young Frederick for preferring poetry, music, and philosophy to military affairs.

Frederik, also spelled *Frederick,* is the name of two kings of Denmark who were members of the House of Schleswig-Holstein-Sonderburg-Glücksburg.

Frederik VIII (1843-1912) ruled Denmark for six years after the death of his father, Christian IX, in 1906. Frederik was born in Copenhagen. He was the brother of Queen Alexandra of England and of King George I of Greece. His second son, Charles, became King Haakon VII of Norway, and his oldest son, Christian X, succeeded him.

Frederik IX (1899-1972), the oldest son of Christian X, was king from 1947 until his death. He had served as crown prince for 35 years and as regent during World War II. He married Princess Ingrid of Sweden in 1935. His oldest daughter, Margrethe, succeeded him.

Free Churches are Protestant Christian Churches in the United Kingdom and Ireland that are distinct from the established Anglican Churches. The leading Free Churches include the Baptists, the Congregationalists, the Methodists, and the United Reformed Church. Other Free Churches include the Brethren, the Churches of Christ, the Salvation Army, the Society of Friends, and the Unitarians.

Beliefs. The Baptist, Congregational, Methodist and United Reformed Churches all believe in Jesus Christ as the Son of God. They believe in the incarnation, the Resurrection, and the miracles performed by Jesus.

The great difference between the Free Churches and the Roman Catholic Church and the Church of England lies in methods of Church government. Roman Catholics and Anglicans accept the succession of bishops, who have handed down faith and authority from the time of Christ. The Free Churches respect tradition and succession but believe that Churches should have no bishops. They should be self governing under the guidance of the Holy Spirit and Biblical authority.

Organization. Congregationalists and Baptists practise a congregational system of Church government. Each local congregation is a Church in its own right, manages its own affairs, and *calls* (appoints) its own ministers. The congregations group themselves into associations or unions on a county and national scale.

Methodists practise a presbyterian system of Church government. Members regard the whole company of their Church throughout the country as the seat of authority, subject to the guidance of the Holy Spirit.

In most Free Churches, a national assembly or conference meets once a year. It represents the membership of the Church. An appointed president, chairman, or moderator presides over it. A national secretary and other appointed officers assist him. The local church is led by a minister, aided by voluntary helpers known as elders, deacons, or stewards.

Activities. Services in Free Churches consist of readings from the Bible, prayers, hymn-singing, and a sermon. Most Free Churches observe, in a simple manner, the sacraments of Baptism and Holy Communion. The Baptists and other Free Churches baptize adults by *total immersion* (see **Baptism**).

Since the 1790's, Free Churches have conducted missionary work throughout the world. Many oppose both gambling and drinking. Free Churches act together through the Free Church Federal Council.

In 1972, the Presbyterian Church of England and the Congregational Church in England and Wales joined to form the United Reformed Church. Some Congregationalists did not accept the union and continued to worship separately.

History. The Church of England separated from the Roman Catholic Church in 1534. It retained the king as its civil head, the archbishops and bishops as its leaders, and the creeds and liturgies as the basis of its services. But some reformers felt Churches should be free from civil rulers and should base their beliefs and practices only on the Bible. These reformers rejected the authority of bishops. They believed that authority should reside in the whole company of a Church, guided by the Holy Spirit.

A Puritan party with these ideals developed rapidly in the Church of England. When they saw that the Church of England would not change, some Puritans broke away from it. In the 1600's, these breakaway groups became what we now know as Baptists and Congregationalists.

During the English Civil War and the Commonwealth, from 1642 to 1660, Puritan ideas seemed likely to prevail. But, with the restoration of the king in 1660, the authorities began opposing the Puritans. In 1662, the Act of Uniformity confirmed that the Church of England would retain the bishops, the creeds, the Book of Common Prayer, and the king as its civil head. About 2,000 ministers and many lay people rejected this act and left the Church of England. They became known as Dissenters or Nonconformists.

The authorities persecuted the Nonconformists until 1689, when the government passed the Toleration Act, allowing the Nonconformists freedom of worship. The Baptists, the Congregationalists, the English Presbyterians, the Society of Friends, and the Unitarians all developed as separate denominations in the 1600's. The Methodists arose in the mid-1700's.

In the early 1990's, Free Churches in the United Kingdom and Ireland had a total membership of about a million. The leading Free Churches in England were Methodists, with about half a million members; Baptists, with about 60,000 members; and the United Reformed Church, with about 120,000 members. In Scotland, the national Church is like a Free Church except for a link with the state. The Church of Scotland has no bishops and is ruled by an assembly of ministers and elders. Its divisional areas are called presbyteries. It has about 820,000 members.

In Wales, Free Churches exist on the same pattern as elsewhere in the United Kingdom. The Church in Wales, with about 116,000 members, agrees in faith and practice with the Church of England. But it broke its links with the state in 1920. The Presbyterian Church of Wales is also known as the Calvinistic Methodist Church of Wales. It dates from the 1730's. It has 68,000 members.

The Presbyterian Church in Ireland has about 256,000 members. Other Free Churches in Ireland are the Reformed Presbyterian Church of Ireland and the Non-Subscribing Presbyterian Church of Ireland.

During the 1970's and 1980's, there was growth in a new type of Free Church, the house church movement. Its members meet in small groups in private houses for worship and prayer meetings. By the early 1990's, the movement had more than 100,000 members.

Related articles in *World Book* include:

Adventists
Baptists
Methodists
Presbyterians
Puritans
Quakers
Salvation Army
Seventh-day Adventists
Unitarians

Free city is an independent or nearly independent city-state with its own government. Many such city-states developed in Germany in the Middle Ages. In the 1200's, the first German free cities received independence from all authority except the Holy Roman emperor as a reward for helping him against the nobles. In 1871, the free cities Bremen, Hamburg, and Lübeck became states of the German Empire. Danzig (now Gdańsk, Poland) and Fiume (now Rijeka, Croatia) were free cities for a time under the League of Nations. Today, Vatican City may be considered a free city. See also **City-state; Gdańsk; Vatican City.**

Free enterprise system. See **Capitalism; Business** (Business in a free enterprise system).

Free-piston engine, sometimes called a *gasifier,* generates hot gases usually used to run a turbine. It can burn nearly any liquid fuel, from paraffin to peanut oil. Most free-piston engines have one or more pairs of pistons mounted facing each other in a cylinder. These pistons work in much the same way as the pistons in a diesel engine, except they are not connected to a crankshaft. See **Diesel engine; Turbine** (Gas turbines).

Burning fuel makes the pistons bounce back and forth against cushions of air trapped in the ends of a compressor cylinder. As the pistons move toward each other, they compress air, raising it to a high temperature. When fuel is injected, it explodes, drives the pistons apart, and produces hot gases. After the explosion, this air forces the gases through the turbine.

Pateras Pescara, a Spanish engineer, is credited with inventing the engine in the 1920's.

Free ports are ports or airports through which goods may pass without attracting customs duties and taxes. Free ports attract a large number of support and service industries and provide an important source of employment and act as an investment incentive.

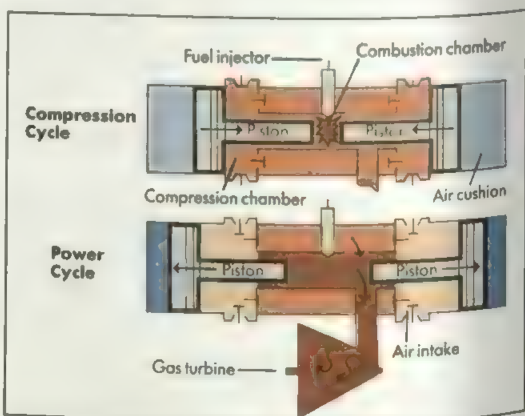
Hong Kong and Singapore are among the world's best known free ports. In the Philippines, the government created a free port zone at Subic Bay after United States forces withdrew from their naval base there in 1992. Malaysia's free ports include Port Klang, Pasir Udang, and the offshore island of Labuan. Free ports in the Caribbean include Kingston and Montego Bay, Jamaica.

An example of a free port that deals with air cargo is the area around Shannon Airport in the Republic of Ireland. It became a duty-free zone in 1947.

Free settlers were people who travelled to Australia of their own free will after 1793. Governor Arthur Phillip asked for farmers to be sent to the colony. Other early governors of New South Wales also began to encourage people to travel to the colony. They offered them such benefits as large land grants, convicts as servants, and positions of responsibility. By 1819, about 1,550 free settlers lived in New South Wales, compared with about 7,560 convicts. By 1851, there were more than 320,000 free settlers.

Free State (FS) is a province in central South Africa. It is completely landlocked. It shares a border with the independent state of Lesotho and with all South Africa's other provinces, except Northern Province and Western Cape. Free State includes parts of the former "homelands" of Qwaqwa and Bophuthatswana. It lies between two of South Africa's main rivers, the Vaal in the north and the Orange in the south.

Free State came into being as Orange Free State in 1854. It was a free republic, but became part of the Union, and later the Republic, of South Africa. It became, with minor alterations, one of South Africa's nine provinces in 1994. The province's main towns are Bloemfontein, the capital, and Welkom. Free State produces a large proportion of South Africa's food and minerals, including gold and uranium.



A free-piston engine works by bouncing pistons off cushions of air. As the pistons move inward, *top,* they compress air between them. Fuel explodes in the combustion chamber, driving the pistons apart, *bottom.* Hot gases escape to drive a turbine.

Free State is one of South Africa's nine provinces. It occupies the area formerly known as Orange Free State.

People. For the total population of Free State, see the *Facts in brief* table with this article. Almost three-quarters of the population live in the main urban centres, mainly in the south of the province. Most of the rest live in rural settlements, mainly in the east. Almost 84 per cent of the inhabitants are black Africans. Europeans and people of mixed ethnic origins make up the remainder.

The main languages spoken are South Sotho, Afrikaans, Xhosa, and Tswana. Some of Free State's people live in poverty. In many rural areas, there is little or no education, health care, running water, or sanitation.

Government. Free State has a 30-seat Provincial Legislature of elected representatives. A provincial premier heads a Cabinet of ministers who carry out the functions of the regional government. Free State has 15 seats in South Africa's National Assembly.

Economy. The economy of Free State depends on its resources and environment. It has valuable natural resources, a developed infrastructure, and a good supply of labour.

The chief sectors of the economy are mining and agriculture. Free State gold fields are the world's largest gold-producing areas. They are centred on Welkom in the northwest. Coal, diamonds, limestone, silver, and uranium are also mined in the province.

Facts in brief about Free State

Population: *1994 estimate:* 2,804,600.
Area: 129,437 km²
Languages: South Sotho, Afrikaans, Xhosa, Tswana
Largest cities: Bloemfontein, Mangaung, Welkom, Kroonstad, Virginia.
Chief products: *Agriculture*—alfalfa, barley, beans, maize, oats, peanuts, peas, potatoes, sorghum, sunflowers, wheat. *Mining*—coal, diamonds, gold, limestone, silver, uranium. *Manufacturing*—chemicals, fuels.

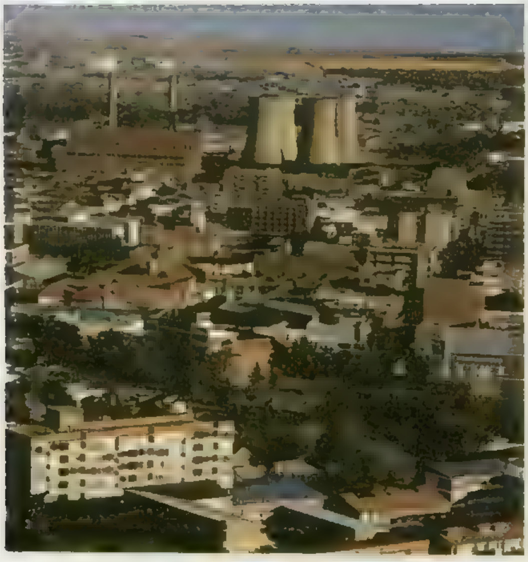
Free State has been called the "food basket" of South Africa. More than 90 per cent of the land is used as farmland. It is the country's main producer of wheat. The province is also a major maize grower, and it produces alfalfa, barley, beans, oats, peanuts, peas, potatoes, sorghum, and sunflowers. Farmers keep cattle, as well as sheep for wool and meat.

Other industries are located in Bethlehem, Bloemfontein-Botshabelo, Harrismith, Phuthaditjhaba, and Welkom. Sasolburg has a major chemical manufacturing and oil refinery plant. The province, because of its central location, is a crossing point for major national roads and rail networks. The Golden Gate Highlands area in the east is a popular tourist venue.

Land. Free State is part of the interior plateau or *highveld* region of southern Africa. It is an area of level plains with gently undulating highland marked by scattered ridges. The western half of the province lies 1,000 to 1,500 metres above sea level. The eastern half is higher, reaching altitudes between 1,500 and 2,000 metres. The eastern half of the province borders on to the Drakensberg mountains, as well as the Maluti range in neighbouring Lesotho. The Rooiberg mountains and Golden Gate area in the northeast are the highest parts. Ribbokkop, one of the highest peaks, rises to 2,840 metres.

The Vaal River, with its main tributaries the Sand, Vet, Renoster, Vals, and Wilge rivers, flows westward and drains the northern part of the province. The Orange, with its tributaries the Caledon, Modern, and Riet rivers, flows westward also and drains the southern areas. Many rivers in the province are *nonperennial* (do not last the whole year). There are numerous *pans* (natural depressions) in the western parts. The main dams are

Workers prepare textiles from wool at a workshop in Phuthaditjhaba (Witsieshoek). The town was the capital of the former "homeland" of Qwaqwa, which became part of Orange Free State when South Africa held its first truly democratic elections in 1994.



Bloemfontein, the capital of Free State, is an extensive modern city with industrial areas, public buildings, and residential suburbs.

Kalkfontein, P. K. Le Roux, Sterkfontein, Vaal, and Hendrik Verwoerd. These dams are important for irrigation, hydroelectricity, and for supplying water to Gauteng.

Climate. The climate of Free State is influenced by the high altitude and distance from the sea. The province experiences a continental-temperate climate. The western parts, which are slightly lower, experience a semiarid climate—hot summers with rainfall between 2.5 and 5 centimetres a year.

The higher eastern segment is more temperate. Summers are cool and rainy, with 5 to 7 centimetres of rain a year. Winters are cold and dry. Most rain falls during the summer months. Frost and snow occur in high-lying areas during winter. See **South Africa** (maps: Precipitation, Temperature).

History. Khoisan hunter-gatherers were the earliest known inhabitants of the region (see **Khoisan**). The Sotho and Tswana settled in the area about 500 years ago. From the 1830's to the 1850's the region was claimed by various groups of European colonists as well as the Sotho leader Moshoeshoe.

When the British abandoned the region to the *Boers* (white Afrikaner settlers) in 1854, the *Griqua* (people of mixed descent), Sotho, and Tswana became rivals for the new Orange Free State. In 1868, Moshoeshoe requested British protection and his kingdom became a British colony, later Lesotho. In 1869, the British handed the Caledon Valley territory to the Orange Free State. Griqua leader Adam Kok III sold his land to the Orange Free State in 1863, and Griqualand West was annexed as a British colony.

After the British won the second Anglo-Boer War (1899-1902), the region became the Orange River Colony. In 1907, it was granted self-government by the United Kingdom. It became a province of the Union of South Africa in 1910. Its name reverted to the Orange Free State.

The 'homelands' of Qwaqwa and Thaba Nchu were reincorporated into the Orange Free State in 1994, when it became a province in the newly democratic Republic of South Africa. In 1995, the state was renamed Free State.

See also **Anglo-Boer Wars; South Africa; South Africa, History of.**

Free State, Irish. See **Ireland, History of** (Independence).

Free trade is the policy of permitting the people of a country to buy and sell where they please without restrictions. A country that has a policy of free trade does not prevent its citizens from buying goods produced in other countries, or encourage them to buy at home.

The opposite of free trade is *protectionism,* the policy of protecting home industries from outside competition. This protection may be provided by placing *tariffs,* or special taxes, on foreign goods; by restricting the amounts of goods that people may bring into the country; or by many other practices.

The theory of free trade is based on the same reasoning as the idea that there should be free trade throughout the regions of a country. For example, consumers in the U.S. state of Indiana gain by buying oranges from California, where the fruit can be grown less expensively. They would also gain by buying woollen goods from the United Kingdom if the goods could be produced there at less cost than in the United States.

Free-trade thinking is based on the principle of *comparative advantage* (see **International trade**). According to this principle, market forces lead producers in each area to specialize in the most efficient production of goods for which their costs are lowest and their profits are highest. Each area imports goods that are costlier for it to produce. Such a policy leads to the greatest total worldwide production, so that consumers receive the largest possible supply of goods at the lowest prices.

Objections to free trade. Despite superior efficiency under free trade, most countries favour some form of protectionism. One reason is the unsettled state of world affairs. Many people believe that, so long as there is risk of war, a country should not be too dependent on foreign supplies. Another reason is the need to support the incomes of local workers and firms. Today, many less developed countries use protectionism to encourage their "infant" industries.

Related articles in *World Book* include:

Customs union	Exports and imports
European Free Trade Association	Smith, Adam
European Union	Tariff

Free verse is a style of poetry that does not follow traditional rules of poetry composition. In writing free verse, poets avoid such elements as regular metre or rhyme. Instead, they vary the lengths of lines, use irregular numbers of syllables in lines, and employ odd breaks at the end of each line. They also use irregular accents and rhythms and uneven rhyme schemes. But free verse is not free from all form. It does use such basic poetic techniques as alliteration and repetition.

Free verse first flourished during the 1800's when the romantic poets adopted the style. Earlier experimentation with the style can be detected in the works of English poet John Milton, who was writing in the 1600's. The American poet Walt Whitman, however, is often consid-

ered the father of free verse, using the style effectively in his "Song of Myself" (1855). Another important innovator of free verse in the 1800's was the English poet, Gerard Manley Hopkins. In the early 1900's, a movement in poetry called *imagism* began using free verse. Such imagist poets as T. S. Eliot and Ezra Pound used free verse to create poetry based on the placement of precise images next to personal commentary. E. E. Cummings, a highly unorthodox American poet, experimented with unusual punctuation and typography. By the mid-1900's, free verse had become the standard verse form in poetry, especially in the works of such poets as Robert Lowell, D. H. Lawrence, and William Carlos Williams.

Each poet mentioned in this article has a biography in *World Book*. For an example of free verse, see Theodore Roethke's poem under *Forms* in the **Poetry** article. See also Metre.

Free will is a term for the free choice most of us assume we have in making decisions. Our moral and legal systems, which praise, blame, reward, and punish, seem to assume that people have free will. If people lack free will, it seems unreasonable to hold them responsible for their decisions and actions. It would be difficult to justify the rewarding or punishing of people for actions they could not help doing.

The idea that there is free will has been questioned because it seems to conflict with the widely held belief in *determinism*. Determinism is the view that every event is already determined by previously existing conditions or causes. According to this view, the present state of the world determines everything that will happen in the future. Then human decisions and actions, like all other events, would be determined by causes that precede them. Critics of free will maintain that our choices are not really free if they are already determined before we make them.

Freebooter. See Pirate.

Freedmen's Bureau was an agency created by the United States Congress to help the slaves freed at the end of the American Civil War (1861-1865). It provided food and shelter for poor people and supervised contracts between former slaves and their employers. The bureau protected the rights of black people, provided opportunities for education, and helped them in many other ways.

In March 1865, Congress created the Bureau of Refugees, Freedmen, and Abandoned Lands. The bureau, better known as the Freedmen's Bureau, was part of the War Department.

United States President Andrew Johnson criticized the bureau's work as unconstitutional meddling in the affairs of the Southern States. Johnson blocked the agency's distribution of abandoned lands to freed slaves. The bureau was finally disbanded in 1872.

Freedom is the ability to make choices and to carry them out. The words *freedom* and *liberty* mean much the same thing. For people to have complete freedom, there must be no restrictions on how they think, speak, or act. They must be aware of what their choices are, and they must have the power to decide among those choices. They also must have the means and the opportunity to think, speak, and act without being controlled by anyone else. However, no organized society can actually provide all these conditions at all times.

From a legal point of view, people are free if society imposes no unjust, unnecessary, or unreasonable limits on them. Society must also protect their rights—that is, their basic liberties, powers, and privileges. A free society tries to distribute the conditions of freedom equally among the people.

Today, many societies put a high value on legal freedom. But people have not always considered it so desirable. Through the centuries, for example, many men and women—and even whole societies—have set goals of self-fulfilment or self-perfection. Many societies have thought it natural and desirable for a few people to restrict the liberty of all others.

Kinds of freedom

Most legal freedoms can be divided into three main groups: (1) political freedom, (2) social freedom, and (3) economic freedom.

Political freedom gives people an opportunity to take part in government decisions. This freedom includes the right to vote, to choose between rival candidates for public office, and to run for office oneself. It includes the right to criticize government policies, which is part of free speech. People who are politically free can form and join political parties and organizations. This right is part of the freedom of assembly.

Most people now realize that political liberty means little unless economic and social freedom support it. For example, the right to vote has little value if people lack the information to vote in their own best interests.

Social freedom includes freedom of speech, of the press, and of religion; freedom of assembly; academic freedom; and the right to due process of law.

Freedom of speech is the right of people to say what they believe. Political liberty depends on this right. People need to hold free discussions and to exchange ideas so they can make an informed decision on political issues. Free speech also contributes to political freedom by making government officials aware of public opinion. See **Freedom of speech.**

Freedom of the press is the right to publish facts, ideas, and opinions without interference. This right extends to radio, television, and films as well as to printed material. Freedom of the press may be considered a special type of freedom of speech, and it is important for the same reasons. See **Freedom of the press.**

Freedom of religion means the right to believe in and to practise the faith of one's choice. It also includes the right to have no religion at all. See **Freedom of religion.**

Freedom of assembly is the right to meet together and to form groups with others of similar interests. It also means that people may associate with anyone they wish. On the other hand, no one may be forced to join an association against his or her will.

Academic freedom is a group of freedoms claimed by teachers and students. It includes the right to teach, discuss, research, write, and publish without interference. It promotes the exchange of ideas and the spread of knowledge.

Due process of law is a group of legal requirements that must be met before a person accused of crime is punished. By protecting an individual against injustice, due process serves as a safeguard of personal freedom. It includes people's right to know the charges against

them. The law also guarantees the right to obtain a legal order called a *writ of habeas corpus.* This writ orders the police to free a prisoner if no legal charge can be placed against the person. It protects people from being imprisoned unjustly. See **Habeas corpus.**

Economic freedom enables people to make their own economic decisions. This freedom includes the right to own property, to use it, and to profit from it. Workers are free to choose and change jobs. People have the freedom to save money and to invest it as they wish. Such freedoms form the basis of an economic system called *capitalism* (see **Capitalism**).

Maintaining freedom

Most countries have institutions for maintaining freedom. Generally, courts of law have this duty. Most people believe that such institutions are necessary to check the power of the state and to ensure that it does not gain complete control over people's lives and property. Written constitutions guarantee freedoms under the law in many countries, at least in theory (see **Government**).

Civil rights. Governments guarantee their citizens certain rights in law in order to make the freedom of all members of the community more secure. These rights are called *civil rights.* The most important civil rights include the right to life, the right to own property, the right to fair trial without undue delay when accused of any offence, the right to take part in peaceful meetings, and the right to move freely within the boundaries of one's country. Some people believe that civil rights are natural rights that belong to every human being. Other people believe that civil rights are merely rights that a government grants its citizens.

Limits on freedom

The laws of every organized society form a complicated pattern of balanced freedoms and restrictions. Some people think of laws as the natural enemies of freedom. *Anarchists* believe that all systems of government and laws destroy liberty (see **Anarchism**). Most people believe that the law both limits and protects the freedom of an individual. For example, it forbids people to hit others. But it also guarantees that people will be free from being hit.

Reasons for limits on freedom. The major reason for restricting freedom is to prevent harm to others. To achieve the goal of equal freedom for everyone, a government may have to restrict the liberty of certain individuals or groups to act in certain ways. Laws banning racial discrimination in employment are an example.

Society limits personal freedom in order to maintain order and keep things running smoothly. When two cars cannot cross a road junction at the same time without colliding, regulations specify which should go first.

Also, every person must accept certain duties and responsibilities to maintain and protect society. Many of these duties limit freedom. For example, a citizen has a duty to vote, to pay taxes, and to serve on a jury. The idea of personal freedom has nearly always carried with it some amount of duty to society.

Limits on political freedom. Democracies divide political power among the branches of government, between government and the citizens, and between the majority and minority parties. These divisions of power restrict various liberties. For example, citizens have the right to vote. As a result, elected officials must respect voter opinion. They are not free to govern as they please. Majority rule does not give the majority party the liberty to do whatever it wants.

Limits on social freedom prevent people from using their liberty in ways that would harm the health, safety, or welfare of others. For example, free speech does not include the right to shout "Fire!" in a crowded theatre if there is no fire. Freedom of speech and of the press do not allow a person to tell lies that damage another's reputation. Such statements are called *slander* if spoken and *libel* if written.

Many governments limit freedom of speech and of the press in order to protect public morals. For example, many countries have laws against *pornography* (indecent pictures and writings). See **Obscenity and pornography.**

A government may limit freedom of religion by forbidding certain religious practices. For example, governments prohibit human sacrifice. Some countries forbid *polygamy* (marriage to more than one person at the same time), though Islam and certain other religions permit the practice.

Most other social freedoms can be restricted or set aside to protect other people or to safeguard the country. For example, people may not use freedom of assembly to disturb the peace or to block public streets. Social freedoms may be suspended by the imposition of martial, or military, law in time of war or rebellion.

Limits on economic freedom. In the past, most governments put few limits on economic freedom. They followed a policy of not interfering in economic affairs.

But since the 1800's, the development of large-scale capitalism has concentrated wealth in the hands of relatively few people. This development has convinced many people that government must intervene to protect underprivileged groups and promote equality of economic opportunity. Such beliefs have led to increased restrictions on big business and other powerful economic groups. Today, in many countries, laws regulate wages, hours, and working conditions; forbid child labour; and guarantee unemployment insurance. Most people believe these laws protect economic freedom rather than violate it.

Economic freedom is also limited when it conflicts with other people's rights or welfare. For example, no one is free to cheat others. The right of hotelkeepers to do what they choose with their property does not allow them to refuse a room to people of a certain race or religion. The freedom of manufacturers to run their factories as they wish does not allow them to dump industrial wastes into other people's drinking water.

History

In ancient Greece and Rome, only the highest classes had much freedom. By about 500 B.C., Athens and several other Greek city-states had democratic governments. Citizens could vote and hold office, but they made up a minority of the population. Women, slaves, and foreigners did not have these rights.

During Rome's years as a republic, from 509 to 27 B.C., the highest classes had many liberties. But the lower classes could not hold public office or marry into

upper-class families. Lowest of all were the slaves, who were a form of property and had no legal rights.

The Middle Ages produced a political and economic system called *feudalism*. Under feudalism, the peasants known as *serfs* had little freedom, but nobles had much. Lower-ranking noblemen furnished troops and paid taxes to a higher-ranking nobleman called their *lord*. The lower-ranking noblemen were known as the lord's *vassals*. Vassals had many important rights. For example, a lord had to call his vassals together and get their permission before he could collect extra taxes. Another custom called for disputes between a vassal and his lord to be settled by a court of the vassal's *peers*—men of the same rank as he.

In 1215, King John of England approved a document called Magna Carta. This document made laws of many customary feudal liberties. For example, it confirmed the tradition that the king could raise no special tax without the consent of his nobles. This provision helped to bring about the development of Parliament. In addition, the document stated that no freeman could be imprisoned, exiled, or deprived of property, except as provided by law. The ideas of due process of law and trial by jury developed from this concept. Most important of all, Magna Carta established the principle that even the king had to obey the law. See **Magna Carta**.

In the Middle Ages, the Christian church restricted freedom of thought in Europe. The church persecuted Jews, Muslims, and others who disagreed with its beliefs. It restricted writings it considered contrary to church teachings. But church teachings also acted as a check on the unreasonable use of political power.

The Renaissance and the Reformation emphasized the importance of the individual. As a result, people began to demand greater personal freedom. Anabaptists and other Protestant groups elected their own ministers and held free and open discussions. These practices carried over into politics and contributed to the growth of democracy and political freedom.

During the Age of Reason, many people began to regard freedom as a natural right. Parliament passed the English Bill of Rights in 1689. This bill eliminated many powers of the king and guaranteed the basic rights and liberties of the English people.

At the same time, the English philosopher John Locke declared that every person is born with natural rights that cannot be taken away. These rights include the right to life and to own property; and freedom of opinion, religion, and speech. Locke's book *Two Treatises of Government* (1690) argued that the chief purpose of government was to protect these rights. If a government did not adequately protect the citizens' liberty, the citizens had the right to revolt.

As the Industrial Revolution spread during the 1700's, the free enterprise system became firmly established. The Scottish economist Adam Smith argued for the free operation of capital and markets, known as *laissez faire,* in his book *The Wealth of Nations* (1776).

During the 1700's, three important French philosophers—Montesquieu, Jean Jacques Rousseau, and Voltaire—spoke out for individual rights and freedoms. Montesquieu's book *The Spirit of the Laws* (1748) called for representative government with separation of powers into executive, legislative, and judicial branches. Rousseau declared in his book *The Social Contract* (1762) that government draws its powers from the consent of the people who are governed. Voltaire's writings opposed government interference with individual rights. Such writings helped cause the French Revolution, which began in 1789. The revolution was devoted to liberty and equality. It did not succeed in making France a democracy, but it did limit the king's powers.

The 1800's brought into practice many beliefs about freedom that had developed during the Age of Reason. In 1830, and again in 1848, revolutionary movements swept over much of Europe. Many European monarchs lost most of their powers. By 1848, the citizens of many countries had won basic civil liberties and at least the beginnings of democratic government. These countries included Belgium, Denmark, and the Netherlands. European nations ended slavery during the 1800's. But European colonialism was extended across Africa and Asia.

Workers gained many important rights during the 1800's. Many countries passed laws that regulated working conditions in factories. Workers won the right to form trade unions.

The 1900's. After World War I ended in 1918, many European nations established representative democracies. A number of them also gave women the right to vote, following the example already set by New Zealand (1893), Australia (1902), and some other countries.

By the 1930's, many people no longer believed that the simple absence of restrictions could make them free. Instead, the idea of freedom expanded to include employment, health, and adequate food and housing.

In 1948, the United Nations General Assembly adopted the Universal Declaration of Human Rights. This declaration listed the rights and freedoms that the UN thought should be the goals of all nations.

Freedom in theory and practice

People can experience many kinds of freedom. Philosophers such as Thomas Hobbes, Locke, Montesquieu, and John Stuart Mill were interested mainly in the ways people may preserve their freedom against the actions of their neighbours and rulers. They were concerned mainly with how people can become independent of influences outside themselves. Other thinkers such as Aristotle, Rousseau, Immanuel Kant, and Georg Hegel were more interested in the quality of a person's freedom. They considered how people could free themselves from the constraints of their desire, so that they might live according to reason, free from the slavery of their passions. Many religious writers have also written about freedom from this point of view. Religious writers are chiefly interested in how people can make themselves perfect.

These two theories of freedom do not necessarily contradict each other. One theory is about individual freedom. The other theory is about spiritual freedom. The person who has both kinds of freedom may be the happiest of all.

Since 1900, freedom has diminished rather than increased in many countries. Under the leadership of the dictator Adolf Hitler, the German Nazis imposed their rule on many European peoples. Communist governments established absolute rule over many peoples who once enjoyed a high degree of freedom. The democratic

revolution in Eastern Europe of the late 1980's and early 1990's helped reverse this trend. Yet even in some countries with democratic governments, the rights of each individual person are not as secure as they once were. Personal liberties and privacies have been eroded, and freedom has diminished where people lack respect for order and justice, on which freedom is based.

Related articles in *World Book* include:

Bill of rights	Democracy
Censorship	Freedom of religion
Civil rights	Freedom of speech
Communism (Restrictions on personal freedom)	Freedom of the press
	Voting

Freedom from Hunger is a worldwide information programme planned by the Food and Agricultural Organization of the United Nations. National branches of the organization in various countries collaborate with religious and other groups. They raise money to alleviate hunger in poor countries. Normally, the funds are spent to bring immediate relief to areas hit by famine.

Freedom of religion is the right of a person to believe in and practise whatever faith he or she chooses. It also includes the right of an individual to have no religious beliefs at all.

Like most rights, freedom of religion is not absolute. The degree of religious freedom that people enjoy varies from country to country. Most countries prohibit religious practices that injure people or that are thought to threaten to destroy society. For example, most governments forbid human sacrifice and many also forbid *polygamy,* the practice of having more than one wife or husband at the same time.

Throughout history, people have been persecuted for their religious beliefs. The denial of religious liberty probably stems from two major sources—personal and political. Religion touches the deepest feelings of many people. Strong religious views have led to intolerance among various faiths. Some governments have close ties to a single religion and consider people of other faiths to be a threat. A government may also regard religion as politically dangerous because religions may place allegiance to God above obedience to the state.

The question of morality has caused many conflicts between church and state. Both religion and government are concerned with morality. They work together if the moral goals desired by the state are the same as those sought by the church. But discord may result if they have different views about morality. An example is the disagreement of many religious people with governments that allow abortion.

Religion has been discouraged or even forbidden in countries ruled by dictators. Before the 1980's, for example, the governments of a number of Communist countries persecuted religion on a large scale. A person's highest allegiance, they believed, belonged to Communism, not to a Supreme Being. Although they did not forbid religion entirely, they made it difficult for people to practise any faith. Beginning in 1989, the Communist governments of many Eastern European countries were replaced with reform governments that permitted more religious freedom.

In some countries that have an official religion, or where most of the people belong to one faith, other faiths do not have religious freedom. For example, Iran, which strictly follows Islam, does not favour other faiths, such as Christianity and Judaism. On the other hand, the United Kingdom and Sweden, which also have an official religion, allow freedom of worship for other religious groups. In some countries that do not have an official religion, members of minority religions may still be at an economic or social disadvantage. Roman Catholics in Northern Ireland, which is mostly Protestant, complain of such unfair treatment.

History. Many ancient peoples permitted broad religious freedom. These peoples worshipped many gods and readily accepted groups with new gods. Jews and, later, Christians could not do so because they worshipped only one God. They believed that allegiance to God was higher than allegiance to any ruler or state.

During the Middle Ages, from about the A.D. 500's to the 1500's, the Catholic Church dominated Europe and permitted little religious freedom. The church persecuted Jews and Muslims. It punished people for any serious disagreement with its teachings. In 1415, the Bohemian religious reformer John Hus was burned at the stake for challenging the pope's authority. However, in the late 1500's the Indian emperor Akbar, a Muslim, set an example of religious toleration by allowing Christians and Hindus to explain their beliefs openly.

The Reformation, a religious movement of the 1500's, gave birth to Protestantism. The Catholic Church and Catholic rulers persecuted Protestant groups in Europe. Many Protestant denominations persecuted Catholics and other Protestant groups as well. People seeking religious freedom emigrated from Europe to the new land of America. But by the 1700's and 1800's, the variety of religions that resulted from the Reformation had led to increased tolerance. But intolerance remained strong in some countries. Poland and Russia, for example, severely persecuted Jews. In the 1930's and 1940's, Nazi Germany killed about 6 million Jews.

Freedom of speech is the right to speak out publicly or privately. The term covers all forms of expression, including books, newspapers, magazines, radio, television, and films. Many scholars consider freedom of speech a natural right.

John Stuart Mill (1806-1873), a British philosopher, argued that freedom of speech is desirable because it enables people to add to their knowledge. Mill said that all statements may be true, partly true, or false. A person should be able to express an opinion that is contrary to what most people believe. If a person expresses a false belief, the true belief will gain in strength by being challenged and proved right. It is also desirable that a person should be able to express an opinion that is partly false and partly true. In disentangling what is true from what is false, people learn and correct their mistakes.

Freedom of speech is a safeguard against unjust rule. People should be free to criticize the laws of their community and the policies of their government. A government is less likely to impose unjust laws on people who can openly criticize its decisions. Without freedom of speech, people cannot have complete political freedom.

In a democracy, freedom of speech is a necessity. Democratic constitutions guarantee people the right to express their opinions freely because democracy is government of, by, and for the people. The people need information to help them determine the best political and

social policies. The governments need to know what most people—and various minorities—believe and want.

Most nondemocratic countries deny freedom of speech to their people. Such governments believe that freedom of speech would interfere with the conduct of public affairs and would create disorder.

Limitations. People who enjoy the rights of free speech must respect other people's rights. A person's freedom is limited by the rights of others—for example their right to maintain their good reputation and their right to privacy. All societies, including democratic ones, put various limitations on what people may say. They prohibit types of speech that they believe might harm the government or the people. But defining such speech can be extremely difficult.

Most democratic countries have four major restrictions on free expression. (1) Laws covering *libel* and *slander* prohibit speech or publication that harms a person's reputation (see **Libel; Slander**). (2) Some laws forbid speech that offends public decency by using obscenities or by encouraging people to commit acts considered immoral. (3) Laws against spying, treason, and urging violence prohibit speech that endangers life, property, or national security. (4) Other laws forbid speech that invades the right of people not to listen to it. For example, a local bylaw might limit the times when people may use loudspeakers in the streets.

The development of freedom of speech in most Western countries has been brought about through the growth of democratic governments based on the rule of law. In other countries, this freedom has grown more slowly or not at all.

Some countries, including the United Kingdom and France, have restrictions on freedom of information and free expression in the interests of national security. Such smaller countries as Denmark and Switzerland have less concern about security and, consequently, fewer restrictions. Ireland perhaps has stricter controls over freedom of expression than does any other Western country. Some of these controls are based on the moral teachings of the Roman Catholic Church, to which about 95 per cent of the Irish people belong.

The rulers of some countries have simply ignored or have taken away constitutional guarantees of freedom of speech. For example, the rulers of China and Iran severely limit freedom of speech. The governments of these countries believe they alone hold the truth. Therefore, they say, any opposition must be based on falsehood and regarded as dangerous.

History. Throughout history, people have fought for freedom of speech. During the 400's B.C., the city-state of Athens in ancient Greece gave its citizens considerable freedom of expression. Later, freedom of speech became closely linked with many struggles for political and religious freedom. These struggles took place during the Middle Ages, from about the A.D. 500's to the 1500's. They also played an important part in the Reformation, a religious movement of the 1500's that gave rise to Protestantism.

In the 1600's and 1700's, a period called the Age of Reason, many people began to regard freedom of speech as a natural right. Such philosophers as John Locke of England and Voltaire of France based this idea on their belief in the importance of the individual. Every person, they declared, has a right to speak freely and to have a voice in the government. The American Thomas Jefferson also expressed this idea when he wrote the American colonists' Declaration of Independence.

During the 1800's, democratic ideas grew and increasing numbers of people gained freedom of speech. At the same time, however, the growth of cities and industry required more and more people to live and work in large groups. To some people, such as the German philosopher Karl Marx, the interests of society became more important than those of the individual. They thought countries could operate best under an intelligent central authority, rather than with democracy and individual freedom.

See also **Censorship; Freedom; Freedom of the press; Public opinion.**

Freedom of the press is the right to publish facts, ideas, and opinions without interference from the government or from private groups. This right applies to the printed media, including books and newspapers, and to the electronic media, including radio and television.

Freedom of the press has been disputed since modern printing began in the 1400's, because words have great power to influence people. Today, this power is greater than ever because of the many modern methods of communication. A number of governments place limits on the press because they believe the power of words would be used to oppose them. Many governments have taken control of the press to use it in their own interests. Most publishers and writers, on the other hand, fight for as much freedom as possible.

Democratic constitutions grant freedom of the press to encourage the exchange of ideas and to check the power of the government. Citizens of democracies need information to help them decide whether or not to support the policies of their national and local governments. In a democracy, freedom of the press applies not only to political and social issues but also to business, cultural, religious, and scientific matters.

Most democratic governments limit freedom of the press in three major types of cases. In such cases, these governments believe that press freedom could endanger individuals, national security, or social morality. (1) Laws against *libel* and *invasion of privacy* protect individuals from writings that could threaten their reputation or privacy (see **Libel**). (2) Laws against *sedition* (urging revolution) and treason work to prevent the publication of material that could harm a nation's security. (3) Laws against *obscenity* (offensive language) aim at the protection of the morals of the people.

Dictatorships do not allow freedom of the press. Dictators believe they alone hold the truth—and that opposition to them endangers the country.

In some countries, freedom of the press is guaranteed under the constitution. But the press also regulates itself to a great extent. Publishers and broadcasters avoid publishing libelous material, obscenities, and other matter that might offend a large number of readers and viewers. Where the media depend heavily on advertising income, they sometimes do not publish material that would displease their advertisers.

In many countries, there are bodies such as the Press Complaints Commission of the United Kingdom that deal with complaints from the public about the conduct

of the press. Advertising practice in the cinema, on television, and on posters is similarly regulated by independent bodies whose task it is to maintain advertising standards and to ensure that advertisements are legal, decent, honest, and truthful.

There are in many countries laws that affect press coverage of court proceedings. For example, a British newspaper may not publish comments on the conduct of a trial that are likely to prejudice the court's reputation for fairness, or publish anything that might tend to influence the result.

The severest restrictions on the press are imposed during times of national emergency, especially wartime. During World War II (1939-1945), for example, the governments of countries involved in the war banned the publication of any material that could interfere with the war effort or harm national security. Censorship departments checked that such material did not appear in newspapers, books, or on radio.

Press restrictions vary greatly from country to country. In the United Kingdom, the press is self-regulating. However, in the early 1990's, the press printed information and pictures of the Royal Family which broke the industry's own rules. Since then, the issue of censorship in the United Kingdom has been under review. In Italy, the press restricts itself on what it prints about the pope. Ireland has strict obscenity laws. Denmark dropped all its obscenity laws during the 1960's.

Sometimes a democratic government tries to ban a book that it thinks breaks national security laws. But the matter is decided in a court of law. Religious groups may protest about a book or film they consider offensive, and try to have it withdrawn by the publisher or distributor.

The governments of many countries have strict overall controls on the press. A number of countries in Asia, Latin America, and the Middle East have censorship boards that check all publications. The censors make sure newspapers and other publications follow government guidelines and agree with official policy.

In a Communist dictatorship, the government usually controls the press and broadcasting media by owning and running newspapers, the radio and television themselves. Communist governments make sure that the press follows party policies.

History. Rulers and church leaders restricted the writing and distribution of certain material even before there was a press. In those days, when everything was written by hand, books considered offensive were banned or burned. Since the A.D. 400's, the Roman Catholic Church has restricted material that it considers contrary to church teachings.

Early printers had to obtain a licence from the government or from some religious group for any material they wanted to publish. In 1644, the English poet and political writer John Milton criticized such licensing in his pamphlet *Areopagitica.* This essay was one of the earliest arguments for freedom of the press. Later, in the 1700's, journalists won the right to report the proceedings of Parliament, and to publish them. This enabled ordinary people to read what had been said. By the 1800's, the press of many countries had considerable freedom.

During the 1900's, most of the "free" press grew to accept its responsibility to the public. Journalists and other media professionals have became far more careful and conscientious about checking facts and reporting the news. In some countries, however, the press lost its freedom. For example, the Fascists in Italy and the Nazis in Germany destroyed press freedom before and during World War II and used the press for their own purposes. Civilian or military dictatorships have ruled many countries in the years since World War II ended in 1945. All these governments have censored the press heavily.

See also **Freedom; Freedom of speech; Journalism** (Journalism around the world); **Censorship.**

Freehold. See Estate.

Freeman-Thomas, Freeman. See Willingdon, Marquess of.

Freemasonry. See Masonry.

Freesia is a fragrant, attractive plant belonging to the iris family. It is a native of South Africa, but gardeners throughout the world cultivate it in greenhouses. It has a *corm* (bulblike stem) and long, narrow leaves shaped like swords. Most freesias have white or yellow flowers, but many colours are possible. The flowers grow in clusters that look like spikes. Many people plant the freesia because the flowers bloom in winter. They plant the corm indoors in late summer. It grows better in a cool greenhouse where the night temperature is not above 10 °C. When the flowers appear, the plant should be watered freely.

Scientific classification. The freesia belongs to the iris family, Iridaceae. It is *Freesia refracta.*

Freestone. See Limestone.

Freethinker is a person who refuses to accept the authority of a church or religious doctrine. A freethinker insists on the freedom to form religious opinions on the basis of his or her own reasoning powers.

The name *freethinker* dates back to the 1700's. The English philosopher Anthony Collins used the term in his *Discourse of Freethinking* (1713). Collins and his friend John Toland argued against the authority of the Christian Church. Later, Lord Bolingbroke and David Hume were among the leading English Freethinkers. In France, Voltaire was the leader of a group of people who argued for "natural" religion, as against revealed

The freesia has lovely, fragrant flowers. Gardeners grow freesias in greenhouses because these plants bloom in winter.

religion. Freethinking became fashionable in Germany during the reign of Frederick the Great (1712-1786). At the present time, few freethinkers belong to organized groups. Modern freedom of religion in most countries, has made such organized bodies unnecessary.

Freetown (pop. 469,776) is the seaport capital of the West African country of Sierra Leone. It stands on the estuary of the Sierra Leone River, and has an excellent harbour. The city has a tropical climate. Temperatures average 27 °C, and rainfall totals about 380 centimetres a year. For the location of the city, see **Sierra Leone** (map).

Industries in Freetown include fish processing, soap production, and ship repair. Exports include chromite, diamonds, ginger, gold, kola nuts, palm oil and kernels, and platinum. British philanthropists founded the city in 1787 as a home for freed slaves.

Freeze-drying is a method of preserving substances by removing water from them. Freeze-drying is used extensively for preserving foods, including coffee, tea, juices, shrimp, chicken, and many fruits and vegetables. Biologists use the process to preserve delicate or small organisms for display or microscopic study. Drug companies use it in preparing many medicines. Freeze-drying is also called *lyophilization.*

In freeze-drying, water in the form of ice is removed from a substance. First, the item is frozen. Then it is placed on trays in a refrigerated vacuum chamber. After air is pumped out of the chamber to create a vacuum, the substance is heated to evaporate the ice within it. A technician controls the rate of heating so that the pressure inside the chamber never rises high enough to enable the heat to melt the ice.

As the ice evaporates, the substance dries and becomes *porous* (full of tiny holes) and spongelike. In this condition, substances can return to their original form almost immediately after water is added.

Because ice does not melt during freeze-drying, the process causes little chemical change in a substance. As a result, freeze-dried foods retain most of their flavour. But freeze-drying is more expensive than drying methods that use the air or sun.

See also **Coffee** (Instant coffee); **Dehydrated food; Food preservation** (Freeze-drying).

Freezing point is the temperature at which a substance changes from a liquid to a solid. The freezing points of different substances vary greatly. Mercury, for example, freezes at −38.87 °C. However, gold has a freezing point of 1063 °C.

The freezing point of a pure substance is identical to its *melting point* (see **Melting point**). For example, water freezes at 0 °C, and its solid form, ice, melts at the same temperature. When a pure substance is at its freezing point, the liquid and solid forms of the substance exist in *equilibrium* (a state of balance) with each other. Unless heat is added or removed, they will remain in that state indefinitely because for each amount of liquid that freezes, an equal amount of solid melts. The heat that must be added to melt a unit quantity of a given substance, or be removed to freeze it, is called the *heat of fusion.*

The composition of a substance affects its freezing point. Pure substances, such as a pure element or a simple compound, freeze at one specific temperature. In contrast, mixtures, which consist of several chemically uncombined substances, freeze over a range of temperatures. Bronze, an alloy of copper and tin, solidifies as the temperature falls from 1000 to 800 °C.

The freezing point of most liquids can be lowered by adding another substance. This fact is the basis for using antifreeze in car radiators during the winter. Antifreeze contains ethylene glycol, which has a freezing point of −13 °C. A mixture of equal parts of ethylene glycol and of water freezes at about −37 °C.

A significant increase in pressure can affect the freezing point. The application of pressure raises the freezing point of gold, mercury, and other substances that contract upon freezing. As these substances solidify, their volume decreases. Pressure promotes this decrease, and so the substances freeze at a temperature above their normal freezing point.

An increase in pressure lowers the freezing point of a few substances, such as antimony, bismuth, and water. These substances increase in volume and expand as they begin to freeze. Added pressure prevents this volume change and expansion from occurring at the normal freezing point. As a result, the substances can freeze only at a lower temperature.

See also **Ice.**

Freight is manufactured goods or raw materials transported from one place to another. Railways still carry a good deal of heavy freight such as coal and other minerals. But in most industrial countries, roads now carry much more freight than railways. Trucks and vans carry freight from factory to store, and from store to customer. Freight is often moved inside *containers.* These are large metal boxes which are loaded onto a truck and can be unloaded directly onto a railway wagon or onto the deck of a cargo ship. The introduction of containerized freight has greatly reduced the work of loading, unloading, and reloading goods.

Shipping provides the least expensive way to send freight and most goods transported across oceans are carried in ships. Since the early 1970's, freight movements have been heavily concentrated in the Asia-Pacific region, making Hong Kong a very important container port. Air freight has increased, especially for urgent freight, but is more expensive. Pipelines are used to move such products as natural gas and crude oil in an economical manner.

See also **Containerization.**

Freighter. See **Ship** (Classification of cargo ships; General cargo ships).

Fréjus Tunnels are two tunnels—one a railway tunnel and the other a road tunnel—that connect the Italian province of Turin with the French province of Savoy. The tunnels run through Fréjus Peak in the Alps. The railway tunnel, which was built between 1857 and 1871, was the first tunnel to be cut through the Alps. The power drill and air compressor were used for the first time in building this tunnel. The railway tunnel is 13.7 kilometres long. It was formerly called Mont Cenis Tunnel, after the name of the railway for which it was built. The road tunnel was completed in 1980 and is 13 kilometres long.

Fremantle (pop. 23,838) is the third busiest port in Australia, after Sydney and Melbourne, and the chief port of Western Australia. It lies at the mouth of the Swan River, about 20 kilometres from Perth. Industry in

Fremantle, in Western Australia, is Australia's principal port on the Indian Ocean. The harbour, built on the Swan River, was opened to shipping in 1897.

Fremantle centres on transport and freight handling. The city also has engineering works, oil industry installations, shipbuilding yards, refrigeration plants, grain stores, and flour mills.

Fremantle also has a thriving tourist industry. It has preserved many of the buildings of its past. Examples from its early days, the convict era, and the late Victorian era of the gold boom years give the city a unique style.

Fremantle is named after Sir Charles Howe Fremantle, who took possession of the western coast of Australia for Britain in 1829. Its harbour, designed by C. Y. O'Connor, was opened in 1897.

Fremantle, Charles. See **Australia** (Exploring the new land).

Frémont, John Charles (1813-1890), an American, sometimes called "The Pathfinder," explored much of the area between the Rocky Mountains of North America and the Pacific Ocean. In 1856, he was the first Republican candidate for president of the United States, but he lost to James Buchanan, a Democrat. He served in the army and navy, and as a United States senator.

As a second lieutenant in the U.S. Army Topographical Corps, Frémont worked as a surveyor in the Carolina mountains. He made his first survey of the Rockies in 1842. Frémont's *Report of the Exploring Expedition to the Rocky Mountains* described this trip, and established his reputation. He also helped produce the first scientific map of the American West.

In June 1856, Frémont became the presidential candidate of the newly formed Republican Party. During the campaign, Democrats argued that Frémont's election would cause the Southern States of America to separate from the Union and possibly lead to civil war. James Buchanan, Frémont's Democratic rival, won the election.

Early in the American Civil War (1861-1865), President Abraham Lincoln gave Frémont command of the Union Army's Western Department. But Frémont issued a proclamation taking over the property of rebelling Missouri slaveowners, and freeing their slaves. His act aroused the public and angered Lincoln, who transferred him to western Virginia. Later, he served from 1878 to 1883 as territorial governor of Arizona.

Frémont was born in Savannah, Georgia, U.S.A., and studied at Charleston College, South Carolina. In 1841, he married Jessie Benton.

See also **Lincoln, Abraham** (Election of 1864).

French, John Denton Pinkstone (1852-1925), Earl of Ypres, a British army officer, commanded the first units of British soldiers sent to France in World War I. French returned to the United Kingdom in December 1915 to lead the home forces. He served as the UK's chief of General Staff from 1912 to 1914. He was lord lieutenant, or British governor, of Ireland from 1918 to 1921. French became a navy midshipman when he was 14 years old, but joined the army four years later.

French, Leonard, (1928-   ), an Australian painter and designer of stained glass, became widely recognised for his monumental stained-glass ceiling in the Great Hall of the National Gallery of Victoria, Melbourne, Australia.

French was born in the Melbourne suburb of Brunswick and studied painting at Melbourne Technical College. He first came to public notice in the 1950s with a series of symbolic works using house paints. His themes were heroic and included the Iliad, the Odyssey, and Genesis. French developed his style from studies of the French painters Fernand Leger and Robert Delauney.

French, Percy (1854-1920), was an Irish singer and songwriter who created songs such as "Phil the Fluther's Ball" (1889). French was famous for storytelling, performing sketches, and singing, sometimes to his own banjo accompaniment. He performed in many countries of Europe and in North America. One of the first songs he wrote was "Abdulla Bulbul Ameer" (1877). Many of his best known songs have an Irish theme, such as "Slattery's Mounted Fut" (1889), "Mat Hannigan's Aunt" (1892), and "Come Back Paddy Reilly" (1912). French wrote the words to "The Mountains of Mourne" (1896). He also wrote musical plays

French was born at Cloonyquin, County Roscommon, Ireland, and educated at Trinity College, Dublin. He began writing and performing in 1890, after a career in engineering.

French Academy is a French organization of intellectuals. It is called *L'Académie Française* in French. Its activities include awarding literary prizes and publishing a dictionary of the French language.

The academy has 40 members, known as the *Forty Immortals.* Once elected, they are members for life. Most are writers, but others have been scientists, sociologists, philosophers, and doctors. In general, a seat in the academy becomes vacant only when a member dies. Individuals who wish to be considered for membership contact academy members to declare their candidacy. The members vote on which person to accept. Until 1894, all members of the academy were French-born male citizens of France. Since then, the academy has included men and women of other nationalities who write in French.

Cardinal Richelieu, a French statesman, founded the academy in 1635. It was suppressed in 1793, during the French Revolution. Napoleon I reorganized the academy in 1803 as part of the Institute of France, a group of learned societies supported by the government.

See also **Institute of France.**

French and Indian War. See **Seven Year's War.**

French bulldog is a strong, heavy little dog. It can weigh from about 8 to 15 kilograms. This bulldog has a more pleasant face than the English one. It has a large, square head, rounded ears, and a short nose. Its chunky body is broader in front than behind. It has soft, loose skin that is usually wrinkled on its face and shoulders. Its coat may be white, yellowish, or brownish, often with darker-coloured patches. See also **Dog** (picture: Non-sporting dogs).

French Canada. See **Quebec; Canada.**

French cricket is a simple game in which the players need only a bat and a soft ball. Any number of players can take part. The batsman stands with his heels together, and his legs form the wicket. Any other player throws the ball at his legs from where he picked it up. The batsman tries to hit it. He is out if the ball hits his legs, if he moves his feet, or if he hits the ball and a fielder catches it before it hits the ground. The successful catcher or thrower takes the batsman's place. If the batsman is out because he moves his feet, the last thrower replaces him. If the batsman hits the ball, he scores runs by passing the bat round his body until a fielder retrieves the ball.

French Equatorial Africa was a federation of four territories in central Africa that was administered by France. It included what are now four independent nations: Central African Republic, Chad, Congo, and Gabon. Each nation has a separate article in *World Book.*

The region formerly called French Equatorial Africa covers 2,510,000 square kilometres. Nearly all the people in the region are black Africans. Bantu-speaking peoples live in the south. Fulah, Sara, and Toubou groups live in the north.

The region has vast forest and mineral resources. The richest known mineral deposits lie in Gabon. Chief products include cotton, rice, meat, peanuts, cacao, coffee, timber, manganese, and oil.

The first French colonists arrived in Equatorial Africa in 1839, and settled on the Gabon River. In 1849, they founded Libreville as the capital of the colony. The capital was later moved to Brazzaville. The four territories of French Equatorial Africa were offered the chance to become independent republics in November 1958. All chose to become self-governing states. They became independent nations in August 1960.

French Foreign Legion. See **Foreign Legion.**

French Guiana is an overseas *department* (administrative district) of France on the northeastern coast of South America. It covers about 91,000 square kilometres and has a population of about 73,000. Cayenne is the capital and largest city.

Almost all the people of French Guiana are blacks or *Creoles* (people of mixed black and white ancestry). Most of the people live along the coast. The interior of French Guiana is largely wilderness. The interior has important mineral and forest resources, but they have not been developed. French Guiana depends heavily on France for financial support.

Historically, French Guiana has been known for its

French Guiana

penal colonies. For about 150 years, France sent convicts to French Guiana. Political prisoners were kept on Devil's Island. Other convicts were kept in prison camps at Kourou and Saint-Laurent. The prison camps were widely known for their cruelty. The French finally closed them in 1945 and sent the prisoners back to France. In the 1960's, France turned the camp at Kourou into a space research centre.

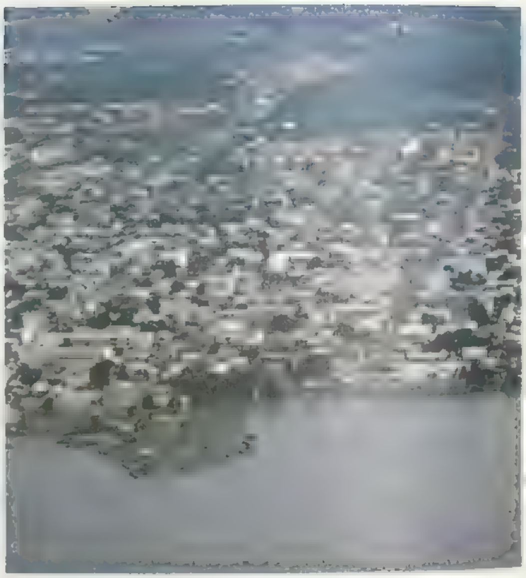
Government. French Guiana was made an overseas department of France in 1946. Its government is like that of France's mainland departments. French Guiana is administered by an elected general council made up of 16 members. The members of the general council elect the president of the department. French Guiana has one representative in each house of the French Parliament. The court system in French Guiana is much like the court system of France (see **France** [Courts]).

People. About 90 per cent of the people of French Guiana are blacks or Creoles. Most are descendants of slaves who were brought to French Guiana during the 1600's and 1700's. Many are Haitians who moved to French Guiana in the 1980's. The rest of the people are American Indians, Chinese, Europeans, Indochinese, Lebanese, and Syrians. The Indians were the first people to live in French Guiana. Today, they live in the interior. Most of the people, however, live along the coast.

Most French Guianans speak French, the department's official language. Many Creoles also speak a dialect that is a mixture of French and English. Most of the people are Roman Catholics.

Children are required by law to attend school. French Guiana has both public and private primary schools, a secondary school, and two vocational schools. About 75 per cent of the people can read and write.

After French Guiana became an overseas department of France in 1946, the French government built hospitals and clinics there. The French government has also waged campaigns to wipe out leprosy, malaria, and tuberculosis in the department.



Cayenne, the capital of French Guiana, lies on an island at the mouth of the Cayenne River. About half the French Guianan people live in the city.

Land and climate. French Guiana has three land regions—a coastal plain in the north, a hilly plateau in the centre, and the Tumuc-Humac Mountains in the south. Rain forest covers most of the country. More than 20 rivers flow north through French Guiana to the Atlantic Ocean. The most important rivers are the Maroni and the Oyapock. The Maroni forms part of the border between French Guiana and Suriname. The Oyapock flows along French Guiana's border with Brazil.

French Guiana has a tropical climate. Temperatures average about 27° C throughout the year. About 330 cen-

Devil's Island, a small isle off the French Guianan coast, was for many years a brutal prison camp for political prisoners of France. The camp was closed in 1945.

timetres of rain falls annually, most of it from December to June.

Economy. French Guiana's economy is not well developed. The department depends on France for money to operate its government, to help support its industries, and to pay for health care and other services. Most of the workers are employed by the government.

French Guiana's chief industries are gold mining and the processing of agricultural and forest products. A shrimp industry is being developed. The leading farm products include bananas, cattle, maize, pineapples, rice, sugar cane, and yams. The farmers do not produce enough food to feed the population, and so much food must be imported.

The interior of French Guiana has rich, well-watered soil; valuable forests; and large deposits of bauxite, an ore used to make aluminium. But these resources have not been developed.

History. The French were the first Europeans to settle in what is now French Guiana. They came in the early 1600's, when many European countries were building colonial empires in the Americas. French Guiana became a French colony in 1667. Since then, the region has been under French control, except for a short period in the early 1800's when it was ruled by British and Portuguese military forces.

France began to send political prisoners to French Guiana during the French Revolution in the 1790's. In 1854, a formal prison system was established in the colony. About 70,000 people were held in the prisons from 1852 to 1945, when France closed them.

French Guiana became an overseas department of France in 1946. Since then, French Guiana has worked, with the help of France, to develop its economy and improve the life of its people. In the 1980's, a strong movement for independence from France developed in French Guiana. But most of the people want French Guiana to remain an overseas department of France.

See also **Cayenne; Penal colony.**

French Guinea. See **Guinea** (country); **French West Africa.**

French horn is a brass musical instrument. It consists largely of a metal tube about 3.7 metres long. The tube is coiled into a circular shape and ends in a large flared bell. The musician produces tones by vibrating the lips in a funnel-shaped mouthpiece. The instrument has three or more valves. The musician fingers the valves with the left hand and places the right hand in the bell for special effects. The player changes notes by moving the valves and changing lip tension. The hand in the bell creates additional pitches and varies the tone qualities. The French horn produces a warm sound that blends well with other instruments.

The French horn is descended from the hunting horn, a coiled valveless instrument sometimes worn around the player's neck. The French composer Jean Baptiste Lully is credited with introducing the French horn into the orchestra about 1664.

See also **Mellophone.**

French language is the official language of France, its overseas territories, and associated states. It is also an official language of Belgium, Canada, Haiti, Luxembourg, Switzerland, and the United Nations. More people speak Chinese, English, Russian, or Spanish than speak French. However, French is so widely spoken that it ranks with English as an international language. More than 90 million people speak French as their mother tongue, and millions of others use it as a second language.

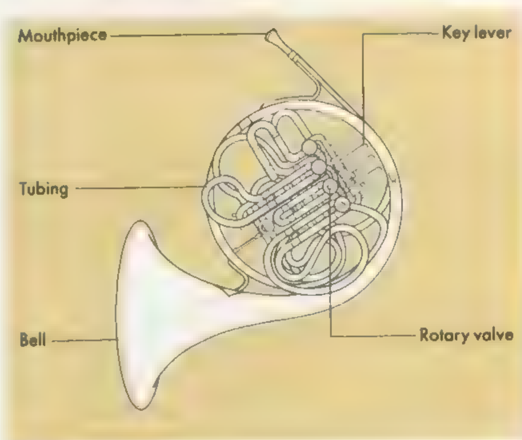
French is a beautiful and harmonious language. It has served for hundreds of years as the language of diplomats. Its clear style and regular *syntax* (arrangement of words) make it especially suitable for diplomatic, legal, and business use, and for literature.

Many of the words in the English language come from French. English began to absorb French words after the Norman conquest of England in 1066. The king's court and courts of justice used French, but the common people continued to speak English. French words gradually became part of English. For example, the words *mouton, boeuf,* and *porc,* which the nobility used instead of *sheep, ox,* and *swine,* became *mutton, beef,* and *pork* in English. Thousands of French terms have been adopted, in whole or in part, into English. They include *art, dress, faith, prison,* and *theatre.*

French grammar

Nouns and adjectives. Few French nouns have *inflections,* which are changes of form (see **Inflection**). All nouns are either masculine or feminine. For example, *le livre* (the book) is masculine, and *la chaise* (the chair) is feminine. In most cases, adjectives are made feminine by adding *e.* For example, the feminine of *petit* (small) is *petite.* Plurals are most commonly formed by adding *s* to the singular. The plural of *le petit livre* is *les petits livres.* The plural of *la petite chaise* is *les petites chaises. Le* and *la* are the masculine and feminine singular forms

The French horn is a metal tube coiled into a circular shape. The instrument ends in a flared bell. A musician uses one hand to press the key levers in various combinations to produce notes. The other hand is placed inside the bell to control the horn's tone.



of the definite article *the*. *Les* is both the masculine plural form and the feminine plural form.

Verbs. French has 14 tenses, 7 simple and 7 compound (see **Tense**). The *simple* tenses are formed by adding endings to the infinitive or to the stem of the verb. The *compound* tenses are made up of the past participle of the verb and an appropriate form of one of the auxiliary verbs *avoir* (to have) or *être* (to be).

In written French, verbs are classified according to the endings of their infinitives. They fall into three groups: *-er* verbs, such as *donner* (to give); *-ir* verbs, such as *finir* (to finish); and *-re* verbs, such as *vendre* (to sell). French has many irregular verbs.

Word order in French is similar to that of English in many cases. A sentence is made negative by placing *ne* before the verb and *pas* after it. A question is formed by inverting the order of the subject and verb or by placing the phrase *est-ce que* (is it that) before the sentence. The following are the affirmative, negative, and interrogative forms of the sentence *John gives the books to my friends:*

Affirmative: *Jean donne les livres à mes amis.*
Negative: *Jean ne donne pas les livres à mes amis.*
Interrogative: *Jean donne-t-il les livres à mes amis?* or *Est-ce que Jean donne les livres à mes amis?*

In the perfect tense, a past tense, the forms are:
Affirmative: *Jean a donné les livres à mes amis.*
Negative: *Jean n'a pas donné les livres à mes amis.*
Interrogative: *Jean a-t-il donné les livres à mes amis?* or *Est-ce que Jean a donné les livres à mes amis?*

Pronunciation of French is often difficult for English-speaking people. The French do not usually pronounce final consonants, except for the letters *c, f, l* and *r*. For example, *lits* (the French word for "beds") is pronounced *lee*, and *et* ("and") is pronounced something like *ay* (as in *day*). At the beginning of French words, consonants such as *p, t* or *c (k)* are pronounced with much less breathiness than in English. The word *tout* ("all") can sound almost, but not quite, like the English word *do*. French vowels are sharp, clear, single sounds. A few do not occur in English. For example, there is no exact equivalent of the *u* in *lune* ("moon"). It is made by first rounding the lips and then trying to pronounce the sound *ee* (as in English *see*). Certain letter combinations signify different sounds in French than they do in English. For example, French *au* or *eau* (in a word like *beau*) is pronounced like *oh*. The letters *ou* are pronounced *oo* (as in English *food*), not *ow* (as in English *now*). The combination *eu* or *oe* or *oeu*, are all pronounced like *u* in English *turn*, but without the *r* being sounded. In some parts of France, for example around the Paris area, the *r* sound is made by vibrating the uvula, a piece of flesh that hangs from the very back of the roof of the mouth.

Development

Beginnings. French is one of the Romance languages, which developed from Latin (see **Romance languages**). When the Roman emperor Julius Caesar conquered Gaul (France) in the 50's B.C., he found the people speaking a language called *Gaulish*. The Gauls gradually adopted the language of the Roman soldiers. This language, called *vernacular* (common) *Latin*, differed from the Latin used by educated people. The Gauls did not learn to speak popular Latin as the soldiers spoke it. They changed the vocabulary on the basis of the way the words sounded. For example, a Gaul hearing the stressed syllables *bon* and *ta* of the word *bonitatem* (kindness) shortened the word to *bonta*. This word has become *bonté* in modern French.

French words and phrases

Numbers

un, one
deux, two
trois, three
quatre, four
cinq, five
six, six
sept, seven
huit, eight
neuf, nine
dix, ten
vingt, twenty
trente, thirty
quarante, forty
cinquante, fifty
soixante, sixty
soixante-dix, seventy
quatre-vingts, eighty
quatre-vingt-dix, ninety
cent, one hundred
mille, one thousand

Days of the week

lundi, Monday
mardi, Tuesday
mercredi, Wednesday
jeudi, Thursday
vendredi, Friday
samedi, Saturday
dimanche, Sunday

Months of the year

janvier, January
février, February
mars, March
avril, April
mai, May
juin, June
juillet, July
août, August
septembre, September
octobre, October
novembre, November
décembre, December

Common words

après, after
aujourd'hui, today
blanc, white
bleu, blue
chose, thing
court, short
dans, in, into
de, of, from
enfant, child
être, to be
femme, woman
fermer, to close
frère, brother
garçon, boy, waiter
gris, grey
jaune, yellow
joli, pretty
madame, madam
mademoiselle, miss
maison, house
mauvais, bad
mère, mother
monsieur, Mr., sir
où, where
père, father
pour, for
rouge, red
sans, without
soeur, sister
vert, green

Common expressions

au revoir, goodbye
bonjour, hello
comment allez-vous? how are you?
merci beaucoup, thank you very much
parlez-vous français? do you speak French?
quelle heure est-il? what time is it?
qu'est-ce que c'est? what is it?
s'il vous plaît, please
très bien, very well

Only about 350 Gaulish words have become part of modern French. The Franks, who invaded Gaul during the A.D. 400's and renamed the country France, contributed about 1,000 words to French. Danish Vikings, who occupied northern France in the 800's, added about 90 words. A number of French words have also come from Greek. As French has developed, its grammar has changed. For example, the language originally had six cases of nouns, as did Latin. French now has two cases. The number of tenses in French has also decreased.

Old French. By the 700's, vernacular Latin had evolved so completely into *la langue romane,* also called Romance, that few could read Latin without a dictionary. The new language first appeared in written form in the Oaths of Strasbourg, a treaty signed by two descendants of the Frankish king Charlemagne in 842.

Beginning in the 900's, Romance developed in France into *Old French,* which had two distinct dialects, each with many minor dialects. The *langue d'oc* flourished in the south, and the *langue d'oïl* prevailed in the north. These terms came from the word for *yes,* which was *oc* in the south and *oïl* in the north. The most famous dialect of the langue d'oc was *Provençal,* the language of the troubadours (see **Troubadour**). A dialect of the langue d'oïl spoken in the area around Paris became the accepted tongue throughout France because of the political influence of the capital.

Modern French. During the Renaissance, a period in European history between about 1300 and 1600, more Greek and Latin words were added to French. In the 1500's, the French people had many contacts with the Spaniards and Italians and adopted a number of Spanish and Italian words.

During the 1600's, writers and scholars began to standardize the structure of French. In 1784, the French author Antoine Rivarol could boast *"Ce qui n'est pas clair n'est pas français"* ("What is not clear is not French"). Today, speakers of French consider it to be one of the most precise languages. A number of English words, such as "weekend," have been added to the French language.

See also **French literature; French Academy.**

French literature is one of the world's richest and most influential national literatures. French writers have contributed to every major literary form, excelling in epic poetry, lyric poetry, drama, and fiction and other types of prose.

French literature has strongly influenced the work of writers in many countries. During the 1600's, the French cultural movement called *classicism* had a major impact on most other European literatures. French writers of the 1700's dominated the intellectual life of Europe. During the 1800's and early 1900's, French literary movements called *realism* and *symbolism* helped shape the work of many British and American writers.

Most French writers have placed special importance on form, language, style, and tradition. They have followed rules and models more closely than writers in other literatures. In general, *rationalism* has been an essential element in French writing. Rationalism emphasizes reason as the governing principle in human conduct. The impact of rationalism has produced writing that is clear, self-controlled, and artistically well-crafted.

Although rationalism has played a vital part in French literature, a strong experimental quality has also appeared in French writing at various times. This experimental writing is often emotional, passionate, and expressed in unorthodox literary forms.

Early French literature

French literature began in the A.D. 800's, during the Middle Ages. Poetry dominated medieval French literature. Much poetry was intended to be sung or recited to largely illiterate audiences by travelling entertainers called *jongleurs.* Gradually, two main kinds of poetry emerged—*lyric* and *narrative.*

Lyric poetry flourished from the 1100's to the 1400's. It began in southern France, where musician-poets called *troubadours* wrote love songs in the Provençal dialect. Some of this poetry was carried to northern France, where it was imitated by poets called *trouvères.* Both the troubadours and trouvères composed lyric poems that praised women and the ideal of love.

The greatest French lyric poet of the Middle Ages was François Villon. He composed ballades and long poems that dealt with the themes of love, failure, and death. His masterpiece is a 2,000-line autobiographical poem called the *Grand Testament* (1461).

Narrative poetry includes four important types: (1) epic poems, (2) romances, (3) lais and contes, and (4) fabliaux. All were written for aristocratic audiences except fabliaux, which were more for the middle class.

Epic poems were tales of warfare and heroic deeds in battle. They were called *chansons de geste* (epic songs). Trouvères composed the chansons to be chanted to musical accompaniment. The most famous was *The Song of Roland* (about 1100). It describes an incident during a campaign led by the famous ruler Charlemagne.

Romances were long fictional works, often filled with fantastic adventures. There were several kinds. *Romans antiques* (classical romances) were based on ancient subjects, such as the Trojan War between Greece and Troy, probably during the 1200's B.C. *Romans bretons* (Breton romances) told stories about King Arthur and his Knights of the Round Table in medieval Britain.

One of the greatest French romances is the *Romance of the Rose.* Guillaume de Lorris wrote the first part in the early 1200's as an *allegory* (symbolic story) about love. Jean de Meung continued the poem from about 1275 to 1280 as a satire on the society of his time.

Lais and contes were short verse tales about chivalry, love, and the supernatural. Lais were based on Celtic sources. Contes were generally based on Latin sources. The poet Marie de France wrote many important lais in the late 1100's.

Fabliaux were short, usually humorous stories that were often satiric and sometimes very coarse. The collection of fabliaux *Romance of Renard* (about 1175 to 1205) uses animal characters to satirize human society.

Early prose included romances that appeared later than verse romances and often told the same stories. Historical chronicles became a major form of prose literature. The best-known historical writers were Philippe de Commines, Jean Froissart, Jean de Joinville, and Geoffroy de Villehardouin.

Early drama was composed primarily in verse and dealt with religious themes. Religious dramas can be grouped into three types. *Mystery plays* dramatized

scenes from the Scriptures. *Miracle plays* portrayed the intervention of the Virgin Mary or saints in human affairs. *Morality plays* were symbolic dramas intended to educate. *Secular* (nonreligious) comedies called *farces* developed as interludes during the performance of religious dramas.

The Renaissance

The Renaissance was a period of European cultural history that began in Italy in about 1300 and spread to other parts of Europe. In French literature, the Renaissance extended from the early 1500's to about 1600.

The French Renaissance was a flowering of learning and literature inspired by ancient Greek and Latin models and by Italian literature. Writers and scholars called *humanists* played a major role in the Renaissance. Humanists combined scholarship with an increased interest in the individual and in worldly, rather than religious, concerns. See **Humanism.**

From 1494 to 1525, French armies invaded Italy. These invasions led to increased contact with Italian art and literature and with Greek humanist scholars. These contacts helped stimulate the Renaissance in France. During the early 1500's, King Francis I and his sister Marguerite of Navarre served as patrons of humanists and other writers in their courts. Marguerite herself was a learned author. She based her collection of tales called the *Heptaméron* (1558) on *The Decameron* by the Italian Renaissance writer Giovanni Boccaccio in the mid-1300's.

François Rabelais was the most important fiction writer of the French Renaissance. His major work is *Gargantua and Pantagruel.* This exuberant, often bawdy, narrative in five parts was published between 1532 and 1564. The work satirizes the legal, political, religious, and social institutions of Rabelais' time.

The Pléiade was a group of seven poets who wanted to create a new kind of French poetry based on ancient Greek and Roman models. Pierre de Ronsard was the leader of the group. His subjects were such common Renaissance themes as love, the passage of youth, and the immortality of the poet.

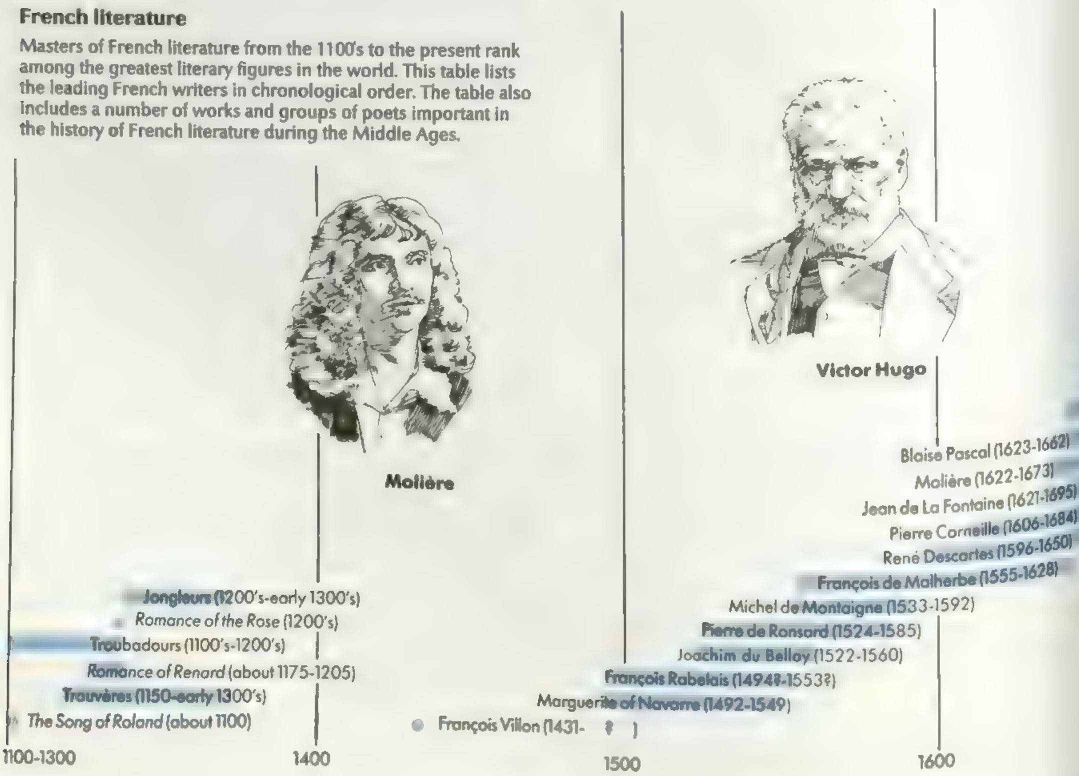
Joachim du Bellay was the second most important Pléiade poet. He was the first French poet to use extensively the sonnet form, which he borrowed from Italian Renaissance poets. Du Bellay wrote an important prose essay called *Defence and Glorification of the French Language* (1549). In the essay, du Bellay "defended" French as a suitable language for poetry against those who favoured Latin, the language used by Roman poets. Du Bellay also urged poets to enrich the French vocabulary with technical words, dialect, and words from Greek and Latin.

Étienne Jodelle was a dramatist as well as a Pléiade poet. He wrote the first original French comedy, *Eugéne* (1552), and the first tragedy, *Cleopatra Prisoner* (1552).

Michel de Montaigne was the last great writer of the French Renaissance. Montaigne created the personal essay as a literary form. A personal essay is written in an informal, conversational style. Montaigne's essays were loosely organized meditations on such topics as education, travel, death, customs, knowledge, and the author himself. A strong sense of scepticism about human nature runs through Montaigne's writings.

French literature

Masters of French literature from the 1100's to the present rank among the greatest literary figures in the world. This table lists the leading French writers in chronological order. The table also includes a number of works and groups of poets important in the history of French literature during the Middle Ages.



The classical age

The reigns of King Louis XIII and especially King Louis XIV are known as the *classical age* in French literature. This period, from about 1600 to the early 1700's, is generally considered to be the high point in French literature.

The classical writers did not reject the ideals of the Renaissance. However, the period developed a greater spirit of order and refinement. French writers especially emphasized reason and the intellect in analysing ideas and human behaviour. See **Classicism**.

Classical poetry. François de Malherbe was the first important classical poet and the most influential. During the early 1600's, Malherbe wrote clear, rational, sober poetry that became the basic style for classical verse. Jean de La Fontaine and Nicolas Boileau-Despréaux were also leading classical poets. La Fontaine wrote a famous collection of animal tales in verse called *Fables* (1668-1694). Boileau wrote *The Art of Poetry* (1674). In this critical work in verse, the author described the literary principles of moderation and nobility of style that characterized classical poetry of his time.

Classical drama was the greatest expression of French classicism. The masters of classical drama were Pierre Corneille, Jean Racine, and Molière.

Corneille was the first great classical writer of tragedy. His plays present noble characters involved in conflicts of duty, loyalty, and love. Corneille stressed the importance of the will, self-control, honour, and freedom. His major tragedies include *The Cid* (1636 or 1637), *Horace* (1640), *Cinna* (1640), and *Polyeucte* (1642).

Racine was the greatest writer of classical tragedy. His plays show characters in the grip of passions they cannot control. A sombre religious pessimism colours his works. Racine adapted ancient Greek and Roman subjects in such masterpieces as *Andromaque* (1667) and *Phèdre* (1677).

Molière was the greatest writer of comedy in French drama. His best plays are satires and present strong characters in conflict with social conventions. Molière wrote his finest comedies in the mid-1660's. They include *Tartuffe*, *Don Juan*, and *The Misanthrope*.

Classical prose. Two philosophers wrote works that rank as masterpieces of French classical prose. René Descartes wrote *Discourse on Method* (1637), an influential example of rationalist thought. Blaise Pascal wrote outstanding prose works that reveal his deep Christian faith. Pascal's best-known religious work is a collection of reflections called *Pensées*. The collection was first published in 1670, though a complete edition was not issued until 1844.

A group of writers called *moralists* described human conduct and manners in letters, sayings called *maxims*, and other prose forms. The satire *The Characters of Theophrastus* (1688) by Jean de La Bruyère is an example of moralist literature. It combines maxims with literary portraits of the people and social types of the day.

Madame de La Fayette wrote one of the first important novels in French literature, *The Princess of Cleves* (1678). The novel has been praised for its psychological analysis and skilful construction.

Jacques Bossuet was a historian and Roman Catholic bishop known for his eloquent and moving sermons.

François de Fénelon was a Roman Catholic archbishop. His literary reputation primarily rests on *Telemachus* (1699), a romance filled with the author's ideas on education, morals, politics, and religion.

The Age of Reason

The 1700's in France are often called the *Age of Reason,* or the *Enlightenment.* During this century, philosophers emphasized reason as the best method for learning truth. Much of the literature was philosophical, produced by such important thinkers as Voltaire, Denis Diderot, and Jean Jacques Rousseau. See **Age of Reason.**

Voltaire was the most famous literary figure of his time. He used his literary skills to fight intolerance and bigotry and to promote rationalism. Voltaire's most famous work is the satirical novel *Candide* (1759). He also wrote tragedies, partly influenced by the plays of William Shakespeare. In addition, Voltaire helped develop the principles of modern historical writing through his many works on European and world history.

Denis Diderot is chiefly known as the editor of the French *Encyclopédie* (1751-1772), one of the great intellectual achievements of the Age of Reason. The *Encyclopédie* was a collection of learned articles contributed by writers in many fields. The work attempted to explain rationally the latest scientific discoveries. It also attacked religious authority, economic inequality, and abuses of justice.

Jean Jacques Rousseau proposed changes in French society in his novel *The New Heloise* (1761) and in education in the novel *Emile* (1762). Rousseau's autobiographical *Confessions* (published in 1782 and 1789, after his death) helped create the modern literature of self-analysis. Rousseau's sensitivity to nature reintroduced a meditative and lyrical feeling into French literature. This sensitivity appears most prominently in *Reveries of the Solitary Stroller* (1782).

Several other major writers contributed to the Age of Reason. Montesquieu wrote witty social criticism in his *Persian Letters* (1721). Alain René Lesage produced a famous satirical novel, *Gil Blas* (1715-1735). The Abbé Prévost composed a popular sentimental novel, *Manon Lescaut* (1731). Pierre Marivaux wrote novels about middle-class society and delicate comedies about problems of love as seen by women. Pierre Beaumarchais wrote the satirical comedies *The Barber of Seville* (1775) and *The Marriage of Figaro* (1784). Both plays deal with the irrational nature of aristocratic privilege and contributed to the ideas that led to the French Revolution (1789-1799).

Romanticism

Romanticism was a movement that had its roots in the late 1700's and flourished during the early and mid-1800's. Romanticism was partly a reaction against classicism and the Age of Reason. Romantic writers rejected what they considered to be the excessive rationalism and lifeless literary forms of previous periods. The romantics emphasized the emotions and the imagination over reason, and they promoted freer forms of literary expression. Romantic writers were extremely self-centred. The writer's personality was often the most important element in a work. See **Romanticism.**

The preromantics. French romanticism was influenced by earlier romantic movements in England, Germany, and Spain. A number of French writers, called *preromantics,* also helped shape the movement during the late 1700's and early 1800's.

Jean Jacques Rousseau is identified with the Age of Reason. However, he was also an important forerunner of romanticism because he prized feeling over reason and spontaneity over self-discipline. Rousseau also influenced the romantics with his lyrical prose style, his introduction of passionate love into the French novel, and his sensitivity to the beauties of nature.

François-René de Chateaubriand exerted a tremendous influence through his fiction. The feelings of boredom, loneliness, and grief that dominate his writings became essential elements of romantic literature. Chateaubriand created a basic character in romantic writing—the solitary, passionate, and misunderstood hero. Chateaubriand had strong religious feelings, and his works helped revive interest in the Christian Middle Ages, a period scorned by writers of classicism and the Age of Reason.

Madame de Staël made a major impact on French romantic critical theory with *On Literature* (1800). She introduced German romanticism into France in *On Germany* (1810). The poet André Chénier incorporated several technical elements into his verse that were adopted by romantic poets.

Romantic poetry began in 1820 with the publication of *Poetic Meditations* by Alphonse de Lamartine. His melancholy poems dealt with nature, love, and solitude.

Victor Hugo was the greatest figure in French romanticism, excelling as a poet, dramatist, and fiction writer. Hugo's *Odes and Diverse Poems* (1822) have a colourful, exotic quality. His later collections, such as *Autumn Leaves* (1831), are more personal and meditative.

Alfred de Vigny is best known for *Antique and Modern Poems* (1826). The poems are philosophical and often dramatic, stressing human unhappiness and the loneliness of the superior individual.

Alfred de Musset had great lyrical gifts. His melancholy and musical poems concern love, suffering, and solitude. In his lyrics called *Nights* (1835-1837), Musset described the anguish he suffered over a lost love.

Romantic drama dealt with historical subjects and melodramatic situations, often mixing comedy with tragedy. The dramas emphasized colour and spectacle, unlike the more controlled dramas of classicism and the Age of Reason. Victor Hugo wrote the first significant romantic play, the historical drama *Hernani* (1830). Vigny and Musset also contributed to romantic drama. Vigny's *Chatterton* (1835) featured a popular character in romantic literature, the neglected artist. Musset wrote sophisticated comedies noted for their verbal brilliance.

Romantic fiction. Many romantic authors wrote historical novels modelled on the works of the Scottish novelist Sir Walter Scott. Alexandre Dumas père (the elder) wrote the famous historical novel *The Three Musketeers* (1844), set during the reign of King Louis XIII in the 1600's. Victor Hugo's *The Hunchback of Notre Dame* (1831) showed the romantic taste for the Middle Ages.

Some romantic writers moved toward a more realistic style of fiction. Such authors as Honoré de Balzac, George Sand, and Stendhal retained many romantic

characteristics in their work. But they modified their romanticism with a more faithful observation of life.

Beginning in 1829, Balzac wrote almost 100 novels and stories that were collected as *The Human Comedy* (1842-1848). In this series, the author attempted to describe the entire French society of his time. Balzac portrayed a wide range of human types, with their motivations and interactions. He also explored the influence of social institutions and values, especially society's attitudes toward money.

George Sand was the pen name of a Frenchwoman who began her literary career by writing novels of love and passion, such as *Indiana* (1832) and *Lélia* (1833). Later, she turned to rural subjects, especially in her novel of country life, *The Haunted Pool* (1846).

Stendhal was a rationalist, but he liked passionate, strong characters and melodramatic situations. A master psychologist, Stendhal used a clear and ironic style to portray the struggle between passion and calculating ambition. His two masterpieces are *The Red and the Black* (1830) and *The Charterhouse of Parma* (1839).

Realism

Realism was a literary doctrine that emerged partly as a reaction against romanticism. The realists believed that art should reproduce life accurately, honestly, and objectively. By the mid-1800's, realism was dominating French literature. See **Realism**.

Gustave Flaubert was the major representative of French realism. He followed Balzac in his love of detail and his careful observation of facts. For his novel *Madame Bovary* (1857), Flaubert deliberately chose an ordinary subject—a dull country doctor and his shallow wife. This portrait of French provincial life ranks among the masterpieces of French literature.

Guy de Maupassant became known for his realistic short stories. De Maupassant was an expert at observing human behaviour. Many of his stories portray provincial life in Normandy or the tedious existence of petty civil servants in Paris.

There were two main types of realistic drama in France. One was the *well-made play,* which emphasized plot and suspense. The comedies of Eugène Scribe are the best examples. The other type was the *problem,* or *thesis, play.* Most dealt with social problems, such as divorce and legal injustice. The leading writers of problem plays were Émile Augier, Eugène Brieux, and Alexandre Dumas fils (the younger).

Literary criticism played a major role in realistic literature and greatly influenced later literary criticism. The leading realistic critic was Charles Sainte-Beuve. He believed that a literary work should be studied through the author's life and personality. He also placed importance on the social environment and historical background in which the work was created.

Naturalism

During the late 1800's, a movement called *naturalism* emerged as an extreme form of realism. Naturalistic writers emphasized the sordid and coarse aspects of human conduct. The typical naturalistic work is pessimistic and often criticizes social injustice. The movement followed a philosophy called *determinism,* which taught that a person's character is determined by environment and heredity rather than free will. See **Naturalism**.

Émile Zola was the leading French naturalistic writer. He proposed to treat fiction as a "laboratory" in which the laws of human behaviour could be discovered. Zola created masterpieces of description and social criticism in his series of 20 novels called *The Rougon-Macquart* (1871-1893). The novels were named after the family that occupies a central place in the stories.

The brothers Edmond and Jules de Goncourt collaborated on *Germinie Lacerteux* (1864), a sombre novel about a servant girl who leads a life of vice. But the brothers were better known for their *Journal,* which recorded the literary and social life of Paris from 1851 to 1896.

Henri Becque was the most important naturalistic playwright. His drama *The Vultures* (1882) is a bitter exploration of ruthless human conduct.

Hippolyte Taine was the leading naturalistic literary critic. Taine developed a deterministic view of literature that can be summarized as *race, milieu, and moment.* Race referred to the author's heredity. Milieu was the author's environment, and moment was the state of the artistic tradition in which the author worked. According to Taine's theory, these three factors governed literary creativity.

Symbolism

French symbolism was a literary movement of the late 1800's. The term *symbolism* has also been applied to the work of a number of French writers who did not belong to the specific movement. See **Symbolism**.

The key figures in the symbolist movement were the poets Charles Baudelaire, Stéphane Mallarmé, Paul Verlaine, and Arthur Rimbaud. They wanted to liberate the techniques of poetry from traditional styles to create freer verse forms. The symbolists believed poetry should suggest meanings through impressions, intuitions, and sensations rather than describe objective reality. Much of the poetry of the symbolists was personal and obscure.

Charles Baudelaire was the forerunner of symbolism. His *Flowers of Evil* (1857) is a collection of about 100 related poems. The work reflects Baudelaire's sombre view of humanity and its vices. However, he wrote that humanity had the potential to create poetic beauty.

Stéphane Mallarmé was the first great symbolist poet. Mallarmé hoped that poetic language could approach absolute truth. His works are difficult to understand because of their unusual syntax, learned words, elaborate metaphors, and abstract subject matter. His most famous poem is *The Afternoon of a Faun* (1876).

Paul Verlaine wrote simple, melodious verse that is delicate, graceful, and musical. In *Songs Without Words* (1874), he tried to create a sense of music in verse.

Arthur Rimbaud was a boy genius. He was producing highly original poetry at the age of 16. At the age of about 19, Rimbaud composed *A Season in Hell* (1873), an autobiographical collection of prose and verse that describes his tortured spiritual experiences.

No symbolist novelist or dramatist equalled the poets. However, the dreamy symbolist plays of Maurice Maeterlinck gained some attention. Maeterlinck was a Belgian author, but he wrote in French.

The 1900's

The four masters. Four authors dominated French literature during the early 1900's. They were Paul Claudel, André Gide, Paul Valery, and Marcel Proust.

Claudel wrote drama, poetry, criticism, and religious commentary that reflected his strong Roman Catholic beliefs. Claudel's poetry is filled with bold metaphors, violent emotions, and flowery language. His best-known works are religious plays, notably *Break of Noon* (written in 1906) and *The Tidings Brought to Mary* (1912).

Gide was a novelist who became controversial because of his unorthodox views on religion and morality. In 1909, he helped found *The New French Review,* the leading French literary journal of the early 1900's.

Proust was perhaps the greatest French novelist since Balzac. His autobiographical novel *Remembrance of Things Past* was published in seven parts from 1913 to 1927. It is a highly personal and poetic work as well as a study of social manners and character psychology.

Valéry wrote poetry that shows the influence of the rational tradition in French literature. His major works include the long poem *The Young Fate* (1917) and the lyrics collected in *Charms* (1922). Valéry was also an outstanding literary critic.

Surrealism was a movement founded in 1924 by a group of writers and painters in Paris. The surrealists wanted to revolutionize society. They explored unconscious thought processes, especially dreams, which they believed would yield ultimate truth. See **Surrealism.** The poet Guillaume Apollinaire was a major influence on surrealism. His *Alcools* (1913) is a collection of beautiful lyrics that celebrate the imagination. The chief theorist and leader of the surrealists was André Breton.

Existentialism was a philosophy that strongly influenced French literature after World War II (1939-1945). Jean-Paul Sartre, the leading existential writer, became famous for such plays as *No Exit* (1944) and *Dirty Hands* (1948) as well as for philosophical writings and criticism. His works explore moral and political topics, especially the problems of freedom and commitment. Simone de Beauvoir helped popularize existentialist ideas in *For a Morality of Ambiguity* (1947). Albert Camus was not strictly an existentialist. But, like Sartre, he explored ethical and moral problems in several works, including the novels *The Stranger* (1942) and *The Plague* (1947) and the long essay *The Myth of Sisyphus* (1942).

French drama of the mid-1900's. Leading playwrights were Jean Anouilh, Jean Giraudoux, and Jean Cocteau. Anouilh explored questions of illusion and reality, the individual against society, and the nature of duty. Giraudoux wrote in a witty, elaborate, artificial style. His plays investigate the nature of love or protest against war and greed. Cocteau became known for his fantasies on mythological subjects.

The 1950's and 1960's saw two major developments in French literature. One was the emergence of the Theatre of the Absurd. Playwrights in this movement tried to dramatize what they believed was the essentially meaningless nature of life. The leading absurdists were Samuel Beckett and Eugène Ionesco. Beckett was Irish and Ionesco was Romanian, but they both wrote in French.

The other major development was the New Novel. Its chief representatives included Alain Robbe-Grillet, Michel Butor, Nathalie Sarraute, and Claude Simon. These writers moved away from traditional approaches to the novel, such as realistic storytelling and plots. Instead, their novels concentrate on descriptions of events and objects as experienced or seen by the characters.

Recent French literature. Since the 1960's, the New Novel has become less important in French literature. Sarraute has concentrated largely on drama, and Robbe-Grillet has become a writer and director of films. Other writers have explored different kinds of novels. J. M. G. Le Clézio writes in a powerful, poetic style about people's struggles to understand the world despite the technological nature of modern life. Michel Tournier often examines issues of human identity and communication. In his novels, Patrick Modiano deals with the topics of memory and the German occupation of France during World War II (1939-1945).

In the 1970's, a feminist movement appeared. A number of women turned their attention to women writers of the past. They also analysed female characters in fiction and the expression of feminist concerns in modern literature. Marguerite Duras and Hélène Cixous are among the leading French feminist writers. Monique Wittig is an extreme feminist writer who believes that the language of literature in the past has represented chiefly a masculine point of view.

During the late 1900's, poetry has continued to be important. Yves Bonnefoy writes brief, philosophical poems in a complex, compact language. The poems of Jean-Claude Renard often reflect almost mystical experiences.

Related articles in *World Book* include:

Early French literature

Chrétien de Troyes
Froissart, Jean
Roland
Troubadour
Trouvère
Villon, François

The Renaissance

Humanism
Marot, Clement
Montaigne, Michel de
Rabelais, François
Renaissance
Ronsard, Pierre de

The classical age

Boileau-Despréaux, Nicolas
Bossuet, Jacques
Classicism
Corneille, Pierre
Cyrano de Bergerac, Savinien de
Descartes, René
Fénelon, François de S.
La Bruyère, Jean de
La Fayette, Madame de
La Fontaine, Jean de
La Rochefoucauld, Duc de
Malherbe, François de
Molière
Pascal, Blaise
Perrault, Charles
Racine, Jean

The Age of Reason

Age of Reason
Bayle, Pierre
Beaumarchais, Pierre de
Diderot, Denis
Lesage, Alain René
Marivaux, Pierre
Montesquieu
Philosophes
Rousseau, Jean Jacques
Sade, Marquis de
Voltaire

Romanticism

Balzac, Honoré de
Chateaubriand, François de
Dumas, Alexandre
Hugo, Victor
Lamartine, Alphonse de
Mérimée, Prosper
Musset, Alfred de
Nerval, Gérard de
Romanticism
Rostand, Edmond
Rousseau, Jean Jacques
Sand, George
Staël, Madame de
Stendhal
Vigny, Alfred

Realism and naturalism

Brieux, Eugène	Naturalism
Daudet, Alphonse	Realism
De Maupassant, Guy	Sainte-Beuve, Charles
Dumas, Alexandre	Scribe, Augustin Eugène
Flaubert, Gustave	Taine, Hippolyte
France, Anatole	Verne, Jules
Goncourt	Zola, Émile
Mistral, Frederic	

Symbolism

Baudelaire, Charles	Rimbaud, Arthur
Gautier, Théophile	Sully-Prudhomme, René
Maeterlinck, Maurice	Symbolism
Mallarmé, Stéphane	Verlaine, Paul

The 1900's

Anouilh, Jean	Colette	Perse, Saint-John
Apollinaire, Guillaume	Existentialism	Prévert, Jacques
Beauvoir, Simone de	Genet, Jean	Proust, Marcel
Beckett, Samuel	Gide, André	Rolland, Romain
Breton, André	Giraudoux, Jean	Romains, Jules
Camus, Albert	Ionesco, Eugène	Saint-Exupéry, Antoine de
Céline, Louis-Ferdinand	Malraux, André	Sartre, Jean-Paul
Claudel, Paul	Martin du Gard, Roger	Surrealism
Cocteau, Jean	Mauriac, François	Valéry, Paul
	Maurois, André	

Other related articles

Drama	French language	Philosophy
Epic	Novel	Poetry
French Academy		

Outline

I. **Early French literature**
   A. Lyric poetry
   B. Narrative poetry
   C. Early prose
   D. Early drama
II. **The Renaissance**
   A. François Rabelais
   B. The Pléiade
   C. Michel de Montaigne
III. **The classical age**
   A. Classical poetry
   B. Classical drama
   C. Classical prose
IV. **The Age of Reason**
V. **Romanticism**
   A. The preromantics
   B. Romantic poetry
   C. Romantic drama
   D. Romantic fiction
VI. **Realism**
VII. **Naturalism**
VIII. **Symbolism**
IX. **The 1900's**
   A. The four masters
   B. Surrealism
   C. Existentialism
   D. French drama of the mid-1900's
   E. Recent French literature

Questions

What were the characteristics of *naturalism*?
When did *existentialism* influence French literature?
Who wrote *Cinna*? *Lélia*? *Flowers of Evil*?
What was the *Pléiade*?
Who were the two leading novelists of the early 1900's?
How did the preromantics influence *romanticism*?
What were *contes*? *Fabliaux*?
When did French literature begin?
Who was the most influential classical poet?
What were the two main types of realistic drama?

French Morocco. See **Morocco** (History).

French Polynesia is an overseas territory of France. It lies in the Pacific Ocean, about 4,500 kilometres south of Hawaii. For location, see **Pacific Islands** (map). The territory is made up of about 120 islands scattered over an area about the size of western Europe. These islands consist mainly of the Austral, Gambier, Marquesas, Society, and Tuamotu island groups. Papeete, on Tahiti—one of the Society Islands—is the territory's capital.

Most of the territory's people are Polynesians. Tourism, agriculture, and fishing are important economic activities. The chief products include coconuts, pearls, and tropical fruits. French Polynesians elect representatives to the French Parliament and vote in French presidential elections.

See also **Marquesas Islands; Society Islands; Tahiti; Tuamotu Islands.**

French Revolution brought about great changes in the society and government of France. The revolution, which lasted from 1789 to 1799, also had far-reaching effects on the rest of Europe. It introduced democratic ideals to France but did not make the nation a democracy. However, it ended supreme rule by French kings and strengthened the middle class. After the revolution began, no European kings, nobles, or other privileged groups could ever again take their powers for granted or ignore the ideals of liberty and equality.

The revolution began with a government financial crisis but quickly became a movement of reform and violent change. In one of the early events, a crowd in Paris captured the Bastille, a royal fortress and prison, which had become a symbol of oppression. A series of elected legislatures then took control of the government. King Louis XVI and his wife, Marie Antoinette, were executed. Thousands of others met the same fate in a period called the Reign of Terror. The revolution ended when Napoleon Bonaparte, a French general, took over the government.

Background. Various social, political, and economic conditions led to the revolution in France. These conditions included much dissatisfaction among the lower and middle classes, interest in new ideas about government, and financial problems caused by the costs of wars.

Legal divisions among social groups that had existed for hundreds of years created much discontent. According to the law, French society consisted of three groups called *estates*. Members of the clergy made up the first estate, nobles the second, and the rest of the people the third. The peasants, who earned very little, formed the largest group in the third estate. The third estate also included the working people of the cities and a large and prosperous middle class made up chiefly of merchants, lawyers, and government officials.

The third estate resented certain advantages of the first two estates. The clergy and nobles did not have to pay most taxes. The third estate had to provide almost all the country's tax revenue. Many members of the middle class were also troubled by their social status. They were among the most economically important people in French society but were not recognized as such because they belonged to the third estate.

The new ideas about government challenged France's *absolute monarchy*. Under this system, the king had almost unlimited authority. He governed by *divine right*—that is, the monarch's right to rule was thought to come from God. There were checks on the king, but these came mainly from a few groups of aristocrats in the *parlements* (high courts). During the 1700's, French writers called *philosophes* and philosophers from other countries raised new ideas about freedom. Some of these

thinkers, including Jean Jacques Rousseau, suggested that the right to govern came from the people.

The financial crisis developed because France had gone deeply into debt to finance fighting in the Seven Years' War (1756-1763) and the American Revolution (1775-1783). By 1788, the government was almost bankrupt. The Parlement of Paris insisted that King Louis XVI could borrow more money or raise taxes only by calling a meeting of the Estates-General. This body, also called States-General, was made up of representatives of the three estates, and had last met in 1614. Unwillingly, the king called the meeting.

The revolution begins. The States-General opened on May 5, 1789, at Versailles, near Paris. Most members of the first two estates wanted each of the three estates to take up matters and vote on them separately by estate. The third estate had as many representatives as the other two estates combined. It insisted that all the estates be merged into one national assembly and that each representative have one vote. The third estate also wanted the States-General to write a constitution.

The king and the first two estates refused the demands of the third estate. In June 1789, the representatives of the third estate declared themselves the National Assembly of France. They gathered at a tennis court and pledged not to disband until they had written a constitution. This vow became known as the Oath of the Tennis Court. Louis XVI then allowed the three estates to join together as the National Assembly. But he began to gather troops around Paris to break up the Assembly.

Meanwhile, the masses of France also took action. On July 14, 1789, a huge crowd of Parisians rushed to the Bastille. They believed they would find arms and ammunition there for use in defending themselves against the king's army. The people captured the Bastille and began to tear it down. At the same time, leaders in Paris formed a revolutionary city government. Massive peasant uprisings against nobles also broke out in the countryside. A few nobles decided to flee France, and many more followed during the next five years. These people were called *émigrés* because they emigrated. The uprisings in town and countryside saved the National Assembly from being disbanded by the king

The National Assembly. In August 1789, the Assembly adopted the Decrees of August 4 and the Declaration of the Rights of Man and of the Citizen. The decrees abolished some feudal dues that the peasants owed their landlords, the tax advantages of the clergy and nobles, and regional privileges. The declaration guaranteed the same basic rights to all citizens, including "liberty, property, security, and resistance to oppression," as well as representative government.

The Assembly later drafted a constitution that made France a limited monarchy with a one-house legislature. France was divided into 83 regions called departments, each with elected councils for local government. But the right to vote and hold public office was limited to citizens who paid a certain amount in taxes.

The Assembly seized the property of the Roman Catholic Church. The church lands amounted to about a tenth of the country's land. Much of the church land was sold to rich peasants and members of the middle class. Money from the land sales was used to pay some of the nation's huge debt. The Assembly then reorganized the Catholic Church in France, required the election of priests and bishops by the voters, and closed the Church's monasteries and convents. Complete religious tolerance was extended to Protestants and Jews. The Assembly also reformed the court system by requiring the election of judges. By September 1791, the National Assembly believed that the revolution was over. It disbanded at the end of the month to make way for the newly elected Legislative Assembly.

The Legislative Assembly. The new Assembly, made up mainly of representatives of the middle class, opened on Oct. 1, 1791. It soon faced several challenges. The government's stability depended on cooperation between the king and the legislature. But Louis XVI remained opposed to the revolution. He asked other rulers for help in stopping it, and plotted with aristocrats and émigrés to overthrow the new government. In addi-

Destruction of the Symbols of the Monarchy, Place de la Concorde, August 10, 1793, an oil painting on canvas by Pierre-Antoine Demachy; Musée Carnavalet, Paris

Hatred of the monarchy in France increased because of King Louis XVI's efforts to end the revolution. Louis was executed on Jan. 21, 1793, and the revolution became more extreme. About seven months later, a crowd in Paris burned a crown and a throne that had belonged to the king, *left.*

tion, public opinion became bitterly divided. The revolution's religious policy angered many Catholics. Other people demanded stronger measures against opponents of the revolution.

The new government also faced a foreign threat. In April 1792, it went to war against Austria and Prussia. These countries wished to restore the powers of the king and émigrés. The foreign armies defeated French forces in the early fighting and invaded France. Louis XVI and his supporters clearly hoped for the victory of the invaders. As a result, angry revolutionaries in Paris and other areas demanded that the king be dethroned.

In August 1792, the people of Paris imprisoned Louis XVI and his family. Louis's removal ended the constitutional monarchy. The Assembly then called for a National Convention to be elected on the basis of universal adult male suffrage, and for a new constitution.

Meanwhile, French armies suffered more military defeats. Parisians feared that the invading armies would soon reach the city. Parisians also feared an uprising by the large number of people in the city's prisons. In the first week of September, small numbers of Parisians took the law into their own hands and executed more than 1,000 prisoners. These executions, called the September Massacres, turned many people in France and Europe against the revolution. A victory by the French Army at Valmy on September 20 helped end the crisis.

The National Convention. The king's removal led to a new stage in the revolution. The first stage had been a liberal middle-class reform movement based on a constitutional monarchy. The second stage was organized around principles of democracy. The National Convention, chosen through an election open to nearly all adult French males, opened on Sept. 21, 1792, and declared France a republic. The republic's official slogan was "Liberty, Equality, Fraternity."

Louis XVI was placed on trial for betraying the country. The National Convention found him guilty of treason, and a slim majority voted for the death penalty. The king was beheaded on the guillotine on Jan. 21, 1793. The revolution gradually grew more radical—that is, more open to extreme and violent change. Radical leaders came into prominence. In the Convention, they were known as the Mountain because they sat on the high benches at the rear of the hall. Leaders of the Mountain were Maximilien Robespierre, Georges Jacques Danton, and Jean Paul Marat. Their bitter opponents were known as the Gironde because several came from a department of that name. The majority of the deputies in the Convention was known as the Plain. The Mountain dominated a powerful political club called the Jacobin Club.

Growing disputes between the Mountain and the Gironde led to a struggle for power, and the Mountain won. In June 1793, the Convention expelled and arrested the leading Girondists. In turn, the Girondists' supporters rebelled against the Convention. Charlotte Corday, a Girondist sympathizer, assassinated Jean Paul Marat in July 1793. In time, the Convention's forces defeated the Girondists' supporters. The Jacobin leaders created a new citizens' army to fight rebellion in France and a war against other European countries. Compulsory military service provided the troops, and rapid promotion of talented soldiers provided the leadership for this strong army.

The Death of Marat (1793), an oil painting on canvas by Jacques Louis David; The Royal Museum of Fine Arts, Brussels, Belgium

The death of Marat spurred on the Reign of Terror. Charlotte Corday, a Girondist sympathizer, fatally stabbed the Jacobin leader while he took a bath, *above.*

Terror and equality. The Jacobin government was both dictatorial and democratic. It was dictatorial because it suspended civil rights and political freedom during the emergency. The Convention's Committee of Public Safety took over actual rule of France, controlling local governments, the armed forces, and other institutions.

The committee governed during the most terrible period of the revolution. Its leaders included Robespierre, Lazare Carnot, and Bertrand Barère. The Convention declared a policy of terror against rebels, supporters of the king or the Gironde, and anyone else who publicly disagreed with official policy.

In time, hundreds of thousands of suspects filled the nation's jails. Courts handed down about 18,000 death sentences in what was called the Reign of Terror. Paris became accustomed to the rattle of two-wheeled carts called *tumbrels* as they carried people to the guillotine. Victims of this period included Marie Antoinette, widow of Louis XVI.

The Jacobins, however, also followed democratic principles and extended the benefits of the revolution beyond the middle class. Shopkeepers, peasants, and other workers actively participated in political life for the first time. The Convention authorized public assistance for the poor, free primary education for boys and girls, price controls to protect consumers from rapid inflation, and taxes based on income. It also called for the abolition of slavery in France's colonies. Most of these reforms, however, were never fully carried out because of later changes in the government.

The revolution ends. In time, the radicals began to struggle for power among themselves. Robespierre succeeded in having Danton and other former leaders executed. Many people in France wished to end the Reign of Terror, the Jacobin dictatorship, and the democratic revolution. Robespierre's enemies in the Convention finally attacked him as a tyrant on July 27 (9 Thermidor by the new French calendar), 1794. He was executed the next day. The Reign of Terror ended after Robespierre's death. Conservatives gained control of the Convention and drove the Jacobins from power. Most of the democratic reforms of the past two years were quickly abolished in what became known as the Thermidorian Reaction.

The Convention, which had adopted a democratic constitution in 1793, replaced that document with a new one in 1795. The government formed under this constitution was called the Directory, referring to the five-man executive directory that governed along with a two-house legislature. France was still a republic, but once again only citizens who paid a certain amount in taxes could vote.

Meanwhile, France was winning victories on the battlefield. French armies had pushed back the invaders and crossed into Belgium, Germany, and Italy.

The Directory began meeting in October 1795. But it was troubled by war, economic problems, and opposition from supporters of monarchy and former Jacobins. In October 1799, a number of political leaders plotted to overthrow the Directory. They needed military support and turned to Napoleon Bonaparte, a French general who had become a hero in a military campaign in Italy in 1796 and 1797. Bonaparte seized control of the government on Nov. 9 (18 Brumaire in the revolutionary calendar), 1799, ending the revolution.

The French Revolution brought France into opposition with much of Europe. The monarchs who ruled the other countries feared the spread of democratic ideals. The revolution left the French people in extreme disagreement about the best form of government for their country. By 1799, most were probably weary of political conflict altogether. But the revolution created the long-lasting foundations for a unified state, a strong central government, and a free society dominated by the middle class and the landowners.

Related articles in *World Book* include:

Biographies

Corday, Charlotte
Danton, Georges Jacques
Du Barry, Madame
Lafayette, Marquis de
Louis (XVI)
Marat, Jean Paul
Marie Antoinette
Mirabeau, Comte de
Napoleon I
Robespierre
Roland de la Platière, M. J.
Sieyès, Emmanuel Joseph
Talleyrand

Background and causes

Bastille
Divine right of kings
Estates-General
Rights of Man, Declaration of the
Rousseau, Jean J.
Versailles

The revolution

Émigrés
Girondists
Guillotine
Jacobins
Marseillaise

Other related articles

Clothing (The 1700's)
Swiss guard
Tricolor
Tuileries

French Somaliland. See Djibouti (country).

French Southern and Antarctic Territories are overseas possessions of France. They include the Kerguelen and Crozet *archipelagos* (groups of islands) and Amsterdam and Saint Paul islands, all in the Indian Ocean. The islands cover about 7,770 square kilometres. The territories include Adélie Coast, an area in Antarctica. A High Administrator and Consultative Council, both appointed by the French government, govern the territories.

Kerguelen Island, the largest island of the territories, covers 6,674 square kilometres. It is about 3,380 kilometres southeast of Madagascar. The Crozet Archipelago lies about 1,370 kilometres west of the Kerguelen group. Both groups of islands are cold, damp, and windy. Penguins, whales, and elephant seals live in the region. Amsterdam and Saint Paul lie about 1,300 kilometres northeast of the Kerguelen group. These islands have a milder climate, and lobster and cod are caught in the surrounding waters.

Only scientists live in the French Southern and Antarctic Territories. They study physical forces within and above the earth, including the weather and animal and plant life.

French West Africa was a federation of eight territories in western Africa. France administered the territories from 1895 to 1958. Dakar, now the capital of Senegal, was the capital. French West Africa included eight territories that are now independent countries: Dahomey (now Benin), French Guinea (now Guinea), French Sudan (now Mali), Ivory Coast, Mauritania, Niger, Senegal, and Upper Volta (now Burkina Faso). For more detailed information on these countries, see their separate articles in *World Book*.

Land. French West Africa spread over 4,633,970 square kilometres. It covered most of the great bulge of Africa that juts into the Atlantic Ocean. French West Africa occupied about one-seventh of the African continent. An area of rolling plains, it has tropical rain forests

French West Africa, *shown in yellow,* was a federation of eight territories in western Africa until 1958. Eight separate and independent countries now occupy this region.

along the southern coasts, a belt of thick grasslands across the centre, and the barren Sahara in the north.

History. Before Europeans took control of what became French West Africa, the people of the region were divided into many groups. Some of the groups were loose associations of families that lived in small areas without centralized authority. Other groups formed more elaborate states, with central governments and large populations.

Several great empires bordered the Sahara. The Ghana Empire was strongest during the A.D. 1000's. The Mali Empire reached its height in the 1300's. The Songhai Empire flourished in the 1500's.

The Portuguese were the first Europeans to explore the west African coast. They arrived in the mid-1400's. Then came the French, the Dutch, and the English. The English were mainly interested in buying slaves they could sell in the West Indies and America. In 1624, King Louis XIII of France granted a French company a charter to trade in Senegal. The French established St. Louis, now a city in Senegal, as a fortified trading post at the mouth of the Sénégal River in 1658.

Throughout the 1700's, Britain and France fought for control of this area. In 1815, Britain finally recognized French control of St. Louis and Gorée at the tip of Cape Verde peninsula. But France did not seriously extend its control throughout French West Africa until the late 1800's. In 1895, France grouped its colonies in western Africa under the authority of a governor general. Dakar became the governor general's headquarters in 1902.

France proclaimed a constitution for the Federation of West Africa in 1904. But many areas were far from being completely controlled. Some remained under military authority until after 1945.

French West Africa became a federation of eight overseas territories within the French Union in 1946. France extended citizenship rights to the Africans, but gave only some of them the right to vote. In 1947, France started an economic development programme for the federation. In 1956, France gave all Africans in the federation the right to vote.

When France adopted a new constitution in 1958, French Guinea voted to leave the French Union and became an independent country. The other seven territories voted to remain associated with France within the new French Community. But by the end of 1958, these territories had voted to become autonomous republics.

In 1959, French Sudan and Senegal united to form the Federation of Mali. They negotiated with France for full independence, but agreed to remain in the French Community. The Federation of Mali broke up in August 1960, and French Sudan became the Republic of Mali. The other five republics then asked for complete independence. All of them had received their freedom by the end of 1960. The republics all became members of the United Nations.

Related articles in *World Book* include:

Arabs	Guinea	Niger
Benin	Ivory Coast	Niger River
Berbers	Mali	Senegal
Burkina Faso	Mauritania	

French West Indies consists of several small islands at the eastern end of the Caribbean Sea (see **West Indies** [map]). It is part of the Lesser Antilles island chain. The French West Indies covers 2,805 square kilometres and has a population of 657,000. It makes up two overseas departments of France. The departments are Guadeloupe, which consists of the island of Guadeloupe and several smaller islands; and Martinique, which consists of the island of Martinique. The French West Indies enjoys a higher standard of living than many of the other Caribbean islands because it receives financial assistance from the French government. The main industries are tourism and the production of sugar cane. See also **Guadeloupe; Martinique.**

Freneau, Philip (1752-1832), was an American poet and journalist. He became known as the "Poet of the American Revolution" for the poetry he wrote attacking the British during the American Revolution (1775-1783). Freneau also wrote descriptive and imaginative poetry about nature. These poems include "The Wild Honey Suckle" (1786) and "The Indian Burying Ground" (1788).

Philip Morin Freneau was born in New York City. He was a sailor during the American Revolution and suffered greatly after being captured by the British. His experiences as a prisoner inspired the poem "The British Prison Ship" (1781). Freneau was active in politics during much of his life. From 1791 to 1793, he edited the *National Gazette,* a newspaper that opposed the Federalist Party led by Alexander Hamilton.

Freon. See **Fluorocarbon.**

Frequency. See **Electric generator** (A simple generator); **Sound** (Frequency and pitch).

Frequency band, also called *waveband,* is a range of radio frequencies set aside for a single broadcasting station. A station's transmitter produces a certain constant *carrier frequency.* But the information being transmitted, such as sound or a TV picture, slightly *modulates* (changes) the carrier frequency. Because of this modulation, each station occupies a range of frequencies for its broadcasts. For example, most amplitude modulation (AM) stations require a frequency band of 5 *kilohertz* above and below the carrier frequency of their transmitters. One kilohertz equals 1,000 *hertz* (cycles per second). The use of separate frequency bands keeps nearby radio or television stations from interfering with one another's broadcasts.

Frequency band also refers to any group of radio frequencies used for one purpose, such as commercial, ship-to-shore, amateur, aeroplane, or police broadcasting. The International Telecommunications Union, based in Geneva, Switzerland, assigns frequency bands. For example, in commercial broadcasting, the frequency band for AM stations ranges from about 500 to 1,600 kilohertz. The range for frequency modulation (FM) stations is from 88 to 108 *megahertz.* One megahertz equals 1 million hertz. TV stations use several bands in the *very high frequency* (VHF) and *ultrahigh frequency* (UHF) ranges (see **Very high frequency waves; Ultrahigh frequency waves**).

See also **Radio** (How radio works).

Frequency modulation, usually called simply FM, is a method of sending sound signals on radio waves. Frequency modulation and *amplitude modulation* (AM) are the two principal means of transmitting music and speech.

A radio wave has a fixed *frequency,* the number of times the wave vibrates per second. It also has a definite

amplitude (size). In frequency modulation, the frequency of the transmitting radio wave is made higher or lower to correspond with the vibrations of the sound to be sent. But the amplitude of the wave is not varied. In contrast, amplitude modulation keeps the frequency of the transmitting wave constant. But it changes the wave's amplitude in accordance with the vibrations of the sound signal being transmitted.

FM has some advantages over AM. It is relatively free of static from thunderstorms and of other types of interference that affect AM broadcasts. FM also provides a more faithful reproduction of music and speech.

One of the main uses of frequency modulation is FM radio broadcasting. The transmission of stereophonic programmes is an important development in this area. In FM stereo broadcasting, sound signals from two microphones or from both *channels* (transmission paths) of a stereo record are sent on the same radio wave. Transmitting a programme by this method is called *multiplexing*. A commercial FM station can transmit special programmes of uninterrupted music in addition to its regular or stereo broadcasts.

Frequency modulation also has other uses. For example, television stations transmit the audio portion of their programmes by this method. Telephone companies also use FM in *microwave radio relaying*, a system designed to send long-distance phone calls.

Edwin H. Armstrong, an American electrical engineer, invented frequency modulation in 1933. FM became widely used in the 1940's.

See also **Radio** (How radio works); **High fidelity system**.

Frere, Sir Henry Bartle Edward (1815-1884), a British colonial official, entered the Indian Civil Service in 1834. He served as chief commissioner of Sind (1850-1859) and governor of Bombay (1862-1867). His administration promoted economic development in Sind. During the Indian mutiny of 1857, his leadership kept Sind and the region of Punjab calm. For these achievements he was honoured with a knighthood. He was made a baronet in 1876 for his improvement of Indian agriculture and education.

In 1877, he became the first high commissioner of South Africa with the task of uniting the British and Dutch South African republics into a single British-run Federation. Opposed by Boer settlers in the Transvaal and by Zulu tribes, Frere tried to destroy the Zulus by provoking a war with them in 1879. Following early British losses, Frere was recalled to England and publicly criticized in 1880.

Fresco is a painting made on fresh plaster, using pigments mixed with water. *Fresco* is the Italian word for *fresh*. To make a fresco, the artist usually first makes a drawing, called a *cartoon*, that is the exact size of the proposed picture. A smaller sketch in colours is also made. Then, fresh lime plaster—as much as can be painted in one day—is laid on the surface of the wall or ceiling that is to be decorated. The artist places the cartoon on the plaster, traces the outline, and then is ready to begin painting.

After mixing the dry pigments with water, the painter brushes them onto the damp plaster. As the plaster sets, it binds the colours permanently to its surface. Work must proceed rapidly because the plaster will not hold

Frescoes (1474) in the Ducal Palace of the Gonzaga family, Mantua, Italy

Colourful frescoes decorated many palaces and public buildings of the Italian Renaissance. The Italian painter Andrea Mantegna painted the frescoes shown above in the palace of a duke.

colours that are applied after it has dried. At the end of the day, any unpainted plaster is cut away, making a clean edge for the next day's work.

The lime in the plaster bleaches many pigments. Only pigments that can resist the action of the lime can be used in fresco painting. Most are earth colours, whose tones are not as bright as those used in oil painting.

Fresco painting reached its height during the Italian Renaissance of the 1400's and 1500's. Among the most celebrated frescoes of that period are Michelangelo's decorations of the Sistine Chapel in the Vatican.

Related articles in *World Book* include:

Cartoon	Giotto	Renaissance (pictures)
Easter (picture: The Resurrection)	Masaccio	Simone Martini
Fra Angelico	Michelangelo	Vatican City (picture: The Sistine Chapel)
Ghirlandajo, Domenico	Mural	
	Painting	
	Raphael	

Fret. See **Guitar**.

Freud, Anna (1895-1982), was an Austrian-born leader in the field of child psychoanalysis, the treatment of children's mental illnesses. Her work was influenced by the psychoanalytical theories of her father, the Austrian psychiatrist Sigmund Freud (see **Freud, Sigmund**).

Anna Freud believed children go through various normal stages of psychological development. She maintained that psychoanalysts must have knowledge of these stages to diagnose and treat mental illness in children. According to her, such knowledge can be ob-

tained only through research involving the direct observation of children.

Freud was born in Vienna. She conducted most of her research at the Hampstead Child Therapy Course and Clinic, which she established in London in 1938. The clinic's activities include the treatment of mentally ill children, helping handicapped youngsters, and training workers in child therapy.

Freud, Sigmund (1856-1939), was an Austrian doctor who revolutionized ideas on how the human mind works. Freud established the theory that unconscious motives control much behaviour. He thus greatly advanced the field of psychiatry. His work has helped millions of mentally ill patients. His theories have brought new approaches in child rearing, education, and sociology and have provided new themes for many authors and artists. Most people in Western society view human behaviour at least partially in Freudian terms.

His life

Freud was born on May 6, 1856, in Freiberg, Moravia, in what is now the Czech Republic. He was the oldest of eight children, and his father was a wool merchant. When Freud was 4 years old, his family moved to Vienna, the capital of Austria. He graduated from the medical school of the University of Vienna in 1881. Freud later decided to specialize in *neurology*, the study and treatment of disorders of the nervous system.

In 1885, Freud went to Paris to study under Jean Martin Charcot, a famous neurologist. Charcot was working with patients who suffered from a condition now called *hysteria*. Some of these people appeared to be blind or paralysed, but they actually had no physical defects. Charcot demonstrated that their real problem was mental, and that the physical symptoms could be relieved through hypnosis.

Freud returned to Vienna in 1886 and began to work extensively with hysterical patients. He gradually formulated ideas about the origin and treatment of mental illness. Freud used the term *psychoanalysis* both for his theories and for his method of treatment. When he first presented his ideas in the 1890's, other doctors reacted with hostility. But Freud eventually attracted a group of followers, and by 1910 he had gained international recognition.

During the following decade, Freud's reputation continued to grow. But two of his early followers, Alfred Adler and Carl Jung, split with Freud and developed their own theories of psychology (see **Adler, Alfred; Jung, Carl**). Freud was constantly modifying his own ideas, and in 1923, he published a revised version of many of his earlier theories. That same year, he learned he had cancer of the mouth. He continued his work, though the cancer made working increasingly difficult. In 1938, the Nazis gained control of Austria. Under their rule, Jews were persecuted. Freud, who was Jewish, went to England with his wife and children to escape persecution. He died there of cancer in 1939.

Freud wrote many works. His most important writings include *The Interpretation of Dreams* (1900), *Three Essays on the Theory of Sexuality* (1905), *Totem and Taboo* (1913), *General Introduction to Psychoanalysis* (1920), *The Ego and the Id* (1923), and *Civilization and Its Discontents* (1930).

His theories

On behaviour. Freud observed that many patients behaved according to drives and experiences of which they were not consciously aware. He thus concluded that the unconscious plays a major role in shaping behaviour. He also concluded that the unconscious is full of memories of events from early childhood—sometimes as far back as infancy. Freud noted that if these memories were especially painful, people kept them out of conscious awareness. He used the term *defence mechanisms* for the methods by which individuals did this. Freud believed that patients used vast amounts of energy in forming defence mechanisms. Tying up energy in defence mechanisms could affect a person's ability to lead a productive life, causing an illness that Freud called *neurosis*.

Freud also concluded that many childhood memories concerned sex. He theorized that sexual functioning begins at birth, and that a person passes through several psychological stages of sexual development. During this passage from infant sexuality to adult sexuality, an individual makes many self-discoveries and learns to control his or her sexual impulses.

Freud believed that the normal pattern of sexual development is interrupted in some individuals. These people become *fixated* at an earlier, immature stage. He felt that such fixation could contribute to mental illness in adulthood.

On the mind. Freud divided the mind into three parts: (1) the *id*, (2) the *ego*, and (3) the *superego*. He recognized that each person is born with various instincts, such as the drive to satisfy hunger and the drive to satisfy sexual needs. The id is the mental representation of these biological instincts. The id does not distinguish between the internal mind and the outside environment. For example, the id stimulates the eating drives, but it makes no distinction between a mental image of food and the food itself.

The ego distinguishes between the internal mind and external reality. It controls behaviour that bridges the gap between mental images and the outside world. For example, the ego directs a hungry person to look for and to eat real food.

The superego governs moral behaviour. It is the mental representation of society's moral code. The superego seeks to limit behaviour based on the drives of the id.

In mentally healthy individuals, the three parts of the mind work in harmony. But in others, the parts may conflict. For example, the superego might oppose all sexual behaviour, thus preventing fulfilment of the id's sexual drives. In such cases, psychological disturbance can result.

Sigmund Freud

On treatment. At first, Freud treated neurotic patients by using the hypnotic techniques he had learned from Charcot. But he modified this approach several years later and simply had patients talk about

whatever was on their minds. He called this technique *free association.* By freely associating—that is, by speaking freely—the patient sometimes came upon earlier experiences that contributed to the neurosis.

Often, however, the painful memories that caused the neurosis were held in the unconscious through defence mechanisms. Freud then analysed the random thoughts that had been expressed during free association. He did this in an effort to penetrate the patient's defence mechanisms. He also interpreted the patient's dreams, which he believed were symbolic clues to unconscious memories. After he felt he understood the root of the problem, Freud talked with the patient about his or her earlier experiences. He paid particular attention to the painful feelings—hostility or love, for example—that the patient directed at Freud himself. Through this *transference* of past feelings to the present, the patient could be relieved of the painful memories. The symptoms of the neurosis might then disappear.

His influence

Freud ranks as one of the most influential thinkers in history. His research and writings changed the way many people thought about human nature. The strongest impact of Freud's theories occurred in psychiatry and psychology. Some psychiatrists and psychologists disagree with certain of his ideas. However, Freud's work on the origins and treatment of mental illness helped form the basis of modern psychiatry. In psychology, Freud especially influenced the field of abnormal psychology and the study of the personality.

Freud's theories on sexual development led to open discussion and treatment of sexual matters and problems. His stress on the importance of childhood helped teach the value of giving children an emotionally nourishing environment. His insights also influenced the fields of anthropology and sociology. Most social scientists accept his concept that an adult's social relationships are patterned after early family relationships.

Attitudes toward antisocial behaviour have also been influenced by Freud. Many parents and teachers believe that behavioural problems can be caused by a child's emotional conflicts. Similarly, many criminologists are convinced that large numbers of people commit crimes because of unconscious drives. Many such people can be helped more effectively by psychiatric care than by a prison sentence.

In art and literature, Freud's theories encouraged understanding of *surrealism* (see **Surrealism**). Like psychoanalysis, surrealistic painting and writing explores the inner depths of the unconscious mind. Freudian concepts have provided subject matter for many authors and artists, and critics frequently analyse art and literature in Freudian terms.

See also **Dream; Libido; Oedipus complex; Psychoanalysis.**

Frey, also called Freyr, was the god of agriculture and fertility in Norse mythology. He was the son of the god Njord and the giantess Skadi. Frey's twin sister, Freyja, was the Norse goddess of love and marriage. Both belonged to the *Vanir,* a special group of peace-loving gods.

Myths tell how Frey flew over the earth in a chariot pulled by a golden boar that lit up the sky. These myths also tell how Frey sailed the seas in a ship large enough to hold all the gods. When Frey was not using his ship, he folded it up and carried it in his pocket.

In ancient times, farmers travelled with an image of Frey in their wagons. They believed this practice made their crops thrive. Many ancient Scandinavian families claimed to be descended from Frey because they thought his presence guaranteed a plentiful harvest and world peace.

See also **Freyja.**

Freyberg, Bernard (1889-1963), Baron Freyberg, was a British military commander in World Wars I and II. He was born in London and was educated at Wellington College, in New Zealand. He won the Victoria Cross in 1916, and in 1917, was promoted to brigadier general.

Throughout World War II, Freyberg commanded the New Zealand Expeditionary Force. In 1941, he commanded the Allied forces in Crete. Later, he fought in northern Africa and in Italy. From 1946 to 1952, he was governor-general of New Zealand. He became a peer in 1952.

Freyja was the goddess of love and marriage in Norse mythology. She was also associated with human fertility and childbirth. Freyja was the daughter of the god Njord and the giantess Skadi. Her twin brother, Frey, was the Norse god of agriculture and fertility. Both Freyja and Frey belonged to a group of peace-loving gods called the *Vanir.* Freyja was known as the Bride of the Vanir because she had many love affairs. According to Norse myths, Freyja originated a powerful kind of witchcraft called *seithr.* In seithr, certain women communicated with spirits to learn about the future. Freyja, as the leader of seithr, travelled in a wagon pulled by cats. See also **Frey.**

Friar is the title applied to a member of one of the Roman Catholic religious orders of men who originally lived as *mendicants* (beggars). The term friar comes from a Latin word that means *brother.* The mendicant orders differ from monastic orders in that they were founded for active ministry in the world, such as preaching and missionary or social work. Friars are therefore more mobile than monks, who generally spend most of their lives in monasteries. Friars live in houses called *friaries.*

Mendicant orders were first officially recognized by the church in the early 1200's. They multiplied rapidly until the second Council of Lyons (1274) suppressed all but four major orders. They were the Dominicans (called Black Friars or Preaching Friars), Franciscans (Grey Friars or Friars Minor), Carmelites (White Friars or Brothers of the Blessed Virgin Mary of Mount Carmel), and an order of Augustinians (Austin Friars or Hermits of St. Augustine). A few other lesser orders survived the suppression or were founded later. At first, mendicants renounced all possessions held in common and depended on *alms* (charity). However, the Council of Trent (1545-1563) authorized the orders to hold goods in common.

See also **Capuchins; Carmelites; Dominicans; Franciscans.**

Friars Minor. See **Franciscans.**

Friars Preachers. See **Dominicans.**

Fricker, Peter Racine (1920-1990), an English composer, used counterpoint and serial techniques, but wrote music with a strong emotional impact. A sensitive

orchestrator, he also composed excellent choral works and chamber music. Fricker was born in London and studied at the Royal College of Music there. He travelled widely as a conductor and as composer in residence at several universities.

Friction is the property that objects have which makes them resist being moved across one another. If two objects with flat surfaces are placed one on top of the other, the top object can be lifted without any resistance except that of gravity. But if one object is pushed or pulled along the surface of the other, there is a resistance caused by friction.

Friction has many important uses. It makes the wheels of a locomotive grip the rails of the track. It allows a conveyor belt to turn on pulleys without slipping. You could not walk without friction to keep your shoes from sliding on the pavement. This is why it is hard to walk on ice. The smooth surface of the ice produces less friction than a pavement and allows shoes to slip.

Friction also has disadvantages. It produces heat that may cause objects to wear. This is why oil and other lubricating liquids are used to fill spaces between moving machinery parts. The liquid reduces friction and makes the parts move more easily and produce less heat.

Kinds of friction. There are three main kinds of friction. *Sliding* or *kinetic* friction is produced when two surfaces slide across each other, as when a book moves across a table. *Rolling friction* is the resistance produced when a rolling body moves over a surface. The friction between a car tyre and a street is rolling friction. *Fluid friction* or *viscosity* is the friction between moving fluids or between fluids and a solid. Thinner fluids have less viscosity than thicker fluids, and usually flow faster. See **Viscosity**.

Laws of friction. The basic law of friction says that the force needed to overcome friction is proportional to the total *normal*, or perpendicular, force pressing one surface against the other. That is, when the weight of a box being pulled across a floor is doubled, the force necessary to pull it must be doubled. When the box weighs four times as much, four times as much force must be used to pull it. The ratio between the weight being moved and the force pressing the surfaces together is called the *coefficient of friction* (*C.F.*). The value of the *C.F.* depends on the type of surfaces moving against each other. The coefficient of friction equals the force needed to move an object divided by the force pressing the surface together. This can be written

$$C.F. = \frac{F}{P}.$$

For example, suppose a force of 30 kilograms force (F) is needed to pull a block weighing 80 kilograms (P) across a flat surface. The coefficient of friction (*C.F.*) equals 30 divided by 80, or 0.375. In the metric system, force is measured in units called *newtons*. Suppose a force of 45 newtons is needed to slide a block weighing 12.2 kilograms. The block presses down with a force of about 120 newtons. This is because gravity at the earth's surface pulls with a force of 9.8 newtons for every kilogram an object weighs, and 9.8 times 12.2 equals almost 120. The coefficient of friction equals 45 divided by 120, or 0.375.

The coefficient of friction varies with the different materials used. The *C.F.* of wood sliding on wood is between 0.25 and 0.50. Metal sliding on metal has a *C.F.* of between 0.15 and 0.20. The frictional force due to rolling friction is about $\frac{1}{100}$ as much as that due to sliding friction. But various conditions, including hardness, smoothness, and diameter of the materials, affect rolling friction. To design machines, engineers must know the various coefficients of friction.

Oil reduces friction. The *C.F.* for iron rolled on oiled wood, for example, would be much less than 0.018. The kind of surface has almost no effect when it is covered with oil or other liquids. The friction then depends on the viscosity of the liquid and the relative speed between the moving surfaces.

See also **Bearing**; **Fire** (How fire is produced); **Heat** (Friction).

Friday is the sixth day of the week. The name comes from the Anglo-Saxon word *Frigedaeg,* which means *Frigg's day.* Frigg was a goddess of love in Norse mythology. The Scandinavians considered Friday their luckiest day. But people today associate Friday the 13th with bad luck. One explanation for this belief is that Christ was crucified on Friday, and 13 men were present at the Last Supper. People have called Friday *hangman's day* because it once was the day for the execution of criminals. In memory of the crucifixion, some Christians fast on Fridays, except on a feast day, such as Christmas. Christians observe *Good Friday* two days before Easter in memory of Christ's suffering. The Jewish Sabbath begins at sunset on Friday. Friday is also a holy day among Muslims. Muslims also celebrate the creation of Adam on Friday.

See also **Black Friday**; **Good Friday**; **Week**.

Friedan, Betty (1921-), is considered the founder of the women's liberation movement in the United States. She first gained fame from her book *The Feminine Mystique* (1963). In this book, she protested that society puts pressure on women to be housewives only and not to seek a career.

In 1966, Friedan helped found the National Organization for Women (NOW) to fight for equal rights for women. She led a nationwide protest called the Women's Strike for Equality on Aug. 26, 1970. That date marked the 50th anniversary of the granting of the vote to U.S. women. In 1971, Friedan helped form the National Women's Political Caucus, which encourages women to seek political office.


Betty Friedan

Betty Naomi Goldstein Friedan was born in Peoria, Illinois, U.S.A. She graduated from Smith College, Northampton, Massachusetts, U.S.A. in 1942.

Friendly society is a British organization that exists to provide financial benefits for its members. Members contribute regularly to a fund. They can then draw on this fund when they are in need. For example, they may draw on it if they are sick, unemployed, or too old to work.

Some friendly societies are *deposit societies.* They

take part of a member's contribution and put it into an account in the person's name. The member may draw money as if the account were a bank account.

In the 1800's, the government encouraged people to form friendly societies. It passed acts to regulate the societies' conduct. Today, most of them are registered with the Registrar of Friendly Societies.

Friends, Religious Society of. See Quakers.

Friendship 7. See Glenn, John Herschel, Jr.

Friese-Greene, William (1855-1921), was an outstanding British inventor of photographic devices. In the late 1800's, he tried ways of depicting movement by projecting a series of photographs rapidly. He opened a photographic business in London and designed film projectors. He also experimented to find a suitable material for film. In 1889, he proposed a sensitized celluloid ribbon film as the most satisfactory medium. He became bankrupt in 1891, but resumed experiments the next year and took out many patents for improvements in cinematographic mechanisms. Friese-Greene was born at Bristol and was educated there at Queen Elizabeth's Hospital.

Frietchie, Barbara, is the heroine of the American writer John Greenleaf Whittier's poem "Barbara Frietchie" (1864). The poem describes a supposed incident during the American Civil War when the Confederate General Stonewall Jackson and his troops marched through Frederick, Maryland. Ninety-year-old Barbara Frietchie was the only resident of the town who risked the anger of the Confederate troops by flying a Union flag. Jackson saw the flag and ordered it shot down. But she grasped the flag as it fell, and waving it defiantly:

> "Shoot, if you must, this old grey head,
> But spare your country's flag," she said.

Jackson was moved by the old woman's bravery and permitted her to fly the flag as the troops marched through the town.

No one knows for sure whether the incident related in Whittier's poem actually occurred. But a woman named Barbara Fritchie (1766-1862), also spelled Frietchie, actually lived in Frederick. A reproduction of her home stands on the supposed site of the incident.

Frigate is a warship used for escort and patrol duty. These ships can launch rockets and torpedoes against submarines. Some frigates have guided missiles for use against aircraft and surface ships. Some larger frigates can carry one or two antisubmarine helicopters. Frigates have radar and sonar to detect enemy aircraft, surface ships, and submarines.

Frigates are slightly smaller than destroyers. The Australian Navy's *River* class ships displace 2,750 metric tons of water, and are 113 metres long. They have steam turbines that propel them at about 27 knots (50 kilometres per hour). Larger frigates include the British Royal Navy's *Broadsword* ships. These displace 4,000 metric tons, are 131 metres long, and have gas turbines that give them a top speed of about 30 knots. The *Broadsword* class ships carry two helicopters, Exocet anti-ship missiles, and close-range missiles for defence against aircraft, as well as torpedoes for use against submarines.

Although frigates are equipped to detect and attack enemy aircraft and missiles, these ships are thinly armoured. In the British *Amazon* class ships, for example, lightweight aluminium was used extensively in their construction. But experience of combat in the Falkland Islands in 1982 demonstrated that steel (which burns less readily) is preferable despite its greater weight.

In the wooden sailing ship era of the 1700's, frigates were fast ships carrying fewer than 50 guns. During World War II (1939-1945) frigates were reintroduced to naval service as small, escort vessels designed to hunt submarines. Today, frigates are the workhorses of the navy.

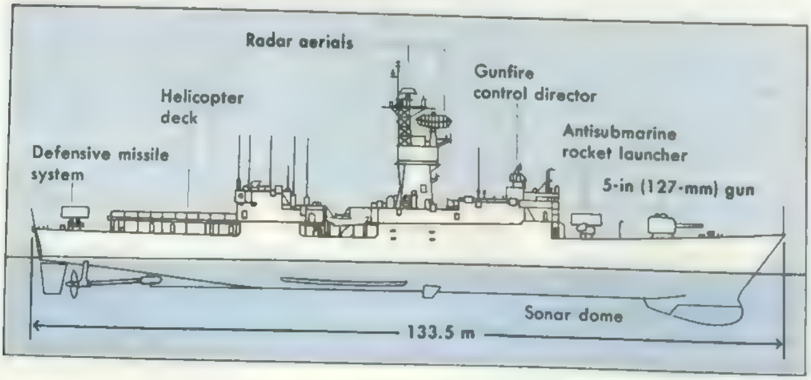
See also **Cruiser; Destroyer.**

Frigatebird is a sea bird with a large wingspread and unusually great powers of flight. People sometimes speak of it as the most graceful bird of the seas. It is a relative of the pelican, and is also called the *man-of-war bird.*

Frigatebirds live in the tropics throughout the world. There are five species. They are about 100 centimetres long, but their wings spread to about 2.5 metres. Black feathers with a metallic sheen cover the upper part of their bodies. The females, or both sexes of some species, have white feathers on the underside. The young birds have white heads. During the nesting season, the male grows a reddish pouch under its bill, which it inflates for courtship displays.

Frigatebirds breed in colonies and build their nests on rocks, high cliffs, or trees on uninhabited islands. They eat fish and squid, which they catch from the surface of the sea or steal from other birds.

Scientific classification. The magnificent frigatebird of tropical Atlantic and eastern Pacific coasts and islands is *Fregata magnificens.* The great frigatebird (Indian and west Pacific



Frigates are warships used for escort and patrol duty. Those of the U.S. *Knox* class, such as the frigate shown on the left, are used largely for antisubmarine warfare.

oceans) is *F. minor;* the lesser frigatebird (mainly South Pacific) is *F. ariel;* the Ascension Island frigatebird is *F. aquila;* the Christmas Island frigatebird is *F. andrewsi.*

See also **Bird** (picture: Sea birds and birds of the Antarctic).

Frilled lizard is a lizard of tropical northern Australia that grows to about 1 metre long. It is recognized by a coloured frill around the neck. When alarmed, the lizard hisses loudly, exposes the bright yellow lining of its mouth, and expands its neck frill. If this tactic does not work against a predator, it can run off quickly on its hind legs, with its forelegs and tail held in the air.

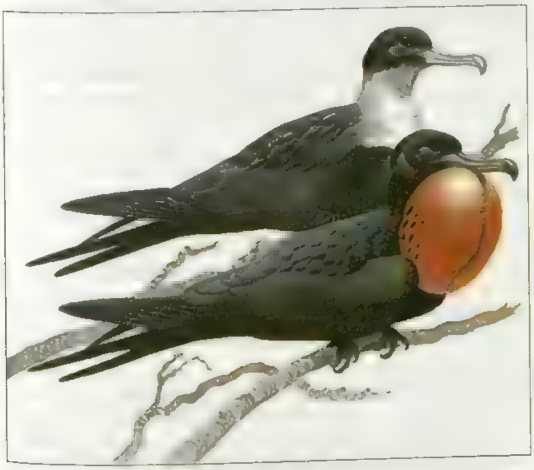
Scientific classification. The frilled lizard belongs to the family Agamidae. It is *Chlamydosaurus kingii.*

Friml, Rudolf (1879-1972), a Czech-born U.S. pianist and composer, was one of the most popular composers of operettas of the early 1900's. Friml wrote more than 20 operettas, gaining immediate fame with his first production, *The Firefly* (1912). His operetta *Rose-Marie* (1924) became the most popular international hit of the 1920's. It features the famous ballad "Indian Love Call." Friml's *The Vagabond King* (1925) contains the well-known "Song of the Vagabonds." Friml composed one of his most popular melodies for the *Ziegfeld Follies of 1923.* After lyrics were added, it became known as "The Donkey Serenade."

Friml was born in Prague, in what is now the Czech Republic, and studied with the famous Czech composer Antonín Dvořák. In 1901, Friml became the piano accompanist for the noted Czech violinist Jan Kubelik. Friml performed in America with Kubelik and as a piano soloist, settling in the United States in 1906. He became a U.S. citizen in 1925. Friml wrote light instrumental pieces until he began composing operettas. In the early 1930's, musical tastes changed and the romantic European style of Friml's compositions seemed outdated. He gave up the theatre and spent the rest of his life composing privately and performing piano concerts.

Fringe tree is a small tree or large shrub named after its threadlike or fringelike white flower petals. It is also called *old man's beard.* The fringe tree grows up to about 10 metres high. Its delicate flowers bloom in early spring.

Frilled lizards display their open frills as a threat to scare off enemies when they are alarmed.

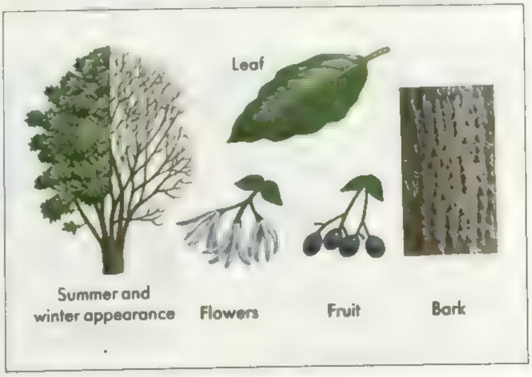


Frigatebirds live in the tropics. The male, *bottom,* grows a reddish pouch during the nesting season.

Fringe trees grow wild in the United States. They thrive on rich, well-drained soil along the banks of rivers and streams. Gardeners plant fringe trees as ornamentals. Fringe trees have hard, heavy, pale-brown wood. The bark contains substances that can be used as medicines. A smaller kind of fringe tree grows wild in China.

Scientific classification. The fringe tree belongs to the olive family, Oleaceae. The common fringe tree is *Chionanthus virginica.* The Chinese species is *C. retusus.*

Frink, Dame Elisabeth (1930-1993), was a British sculptor noted for the solidity and strength of her work in bronze. One of her works, *Bird,* is often reproduced. Frink was born at Thurlow, in Suffolk, England, and educated at the Convent of the Holy Family, Ex-



The fringe tree is named after its delicate threadlike or fringelike white flower petals that bloom in the early spring. The tree's bark contains substances that can be used as medicines.

Elisabeth Frink's ***Bird*** displays the strength and solidity for which the artist's bronze sculptures are noted.

mouth, Devon, England. From 1947 to 1953, she studied at the Guildford and Chelsea schools of art. She also taught sculpture at Chelsea and St. Martin's schools of art and was visiting instructor at the Royal College of Art. She became a Dame Commander of the Order of the British Empire in 1982. In 1985, she exhibited her work at the Royal Academy, London.

Frisbee is a plastic, saucer-shaped disc that skims through the air when flipped with the hand. It is used both in recreation and in organized sporting events. The word *Frisbee* is a trademark for a popular brand of the disc. Most discs measure between about 20 and 28 centimetres in diameter, and weigh between 100 and 175 grams.

The disc can be thrown in many different ways to provide both rotational spin and forward motion. By controlling the angle of release, a player can make a disc curve, skip, hover, or travel in a straight line. Skilled players can catch a disc between the legs, behind the back, or on one finger. An experienced player can toss a disc 70 metres or farther. Several events have been developed involving competition in throwing and catching the disc.

Frisbee can be thrown in many different ways. By controlling the angle of release, a disc can be made to curve, skip, hover, or travel in a straight line.

Frisch, Karl von (1886-1982), an Austrian zoologist, was a pioneer in the field of animal behaviour. Frisch and two naturalists who also studied animal behaviour—Konrad Lorenz of Austria and Nikolaas Tinbergen, who was born in the Netherlands—won the 1973 Nobel Prize for physiology or medicine.

Frisch's best-known work dealt with the communication system of bees. He discovered that bees "dance" in certain patterns to tell members of their hive where to find food. These patterns can indicate the distance and direction of food from the hive (see **Bee** [Swarming; Finding food; diagram: Locating food]). In another study, Frisch showed that bees have a sophisticated system of direction finding, based on the position of the sun. Frisch also showed that fish can see colours. Scientists had previously thought fish were colour-blind.

Frisch was born in Vienna. He studied at the Universities of Munich, Germany, and Vienna and received a Ph.D. degree from the latter institution in 1910. From 1910 to 1958, Frisch taught at several European universities. He retired in 1958. Frisch wrote many books, including *Bees: Their Vision, Chemical Senses, and Language* (1971) and *A Biologist Remembers* (1967), an autobiography.

Frisch, Max (1911-1991), was a Swiss author who became one of the leading writers in the German-speaking world after World War II. His novels and plays concern the problem of identity and the question of how individuals can find their true self.

According to Frisch, the images imposed on us by others, and the images we in turn impose on others, falsify and destroy the authenticity of human personality and individual existence. In his novels *I'm Not Stiller* (1954), *Homo Faber* (1957), and *Wilderness of Mirrors* (1964), Frisch shows the shallowness of how individuals view others and the inability to understand one's own identity. Frisch's plays, notably *Don Juan and the Love for Geometry* (1953), *The Firebugs* (1957-1958), and *Andorra* (1961), deal with the same themes. Frisch was born in Zurich, Switzerland. He worked as an architect before becoming a writer.

Frisch, Ragnar (1895-1973), a Norwegian economist, shared the 1969 Nobel Prize for economics with Jan Tinbergen of the Netherlands. The two men received the award for their work on the development of mathematical models used in *econometrics* (mathematical analysis of economic activity). The Nobel Prize for economics was awarded for the first time in 1969.

Frisch was born in Oslo, Norway, and graduated from Oslo University. He served as a professor in social economy and statistics at the university from 1931 until his retirement in 1965. Frisch led a number of theoretical investigations concerning production, economic planning, and national accounting. He helped establish the Econometric Society in 1930 and was chief editor of its journal, *Econometrica,* until 1955. Frisch also served as an adviser to various developing countries, including Egypt and India.

Fritillary is the name given to a group of medium-sized orange and brown coloured butterflies. Fritillaries are strong fliers. They live in grassland and woodland habitats. Their larvae feed on a wide range of plants, including violets and plantains. One of the largest species is the *silver-washed fritillary,* which has a wingspan of 6

Fritillary is the name of a group of grassland and woodland butterflies. They are orange and brown, and are strong fliers.

Fritillaries are lilies with bell-shaped flowers. The snake's head fritillary, *above*, has chequered or veined purple flowers.

centimetres. It has a wide distribution, from southern Britain, across mainland Europe and Asia to Japan. It often feeds on bramble blossom. The *Queen of Spain fritillary* is another widespread species. It has a beautiful patchwork of silver spots on the underside of its hind wing.

Scientific classification. Fritillaries form part of the brush-footed butterfly family Nymphalidae, subfamily Argynninae. The silver-washed fritillary is *Argynnis paphia;* the Queen of Spain fritillary is *Issoria lathonia.*

Fritillary is the common name for a *genus* (group) of herbs that belong to the lily family. There are nearly a hundred different species. The plants grow throughout the North Temperate Zone, with the exception of eastern North America. Fritillaries have nodding, bell-shaped flowers. All fritillaries bloom in the spring. Most fritillaries are hardy plants, and grow well in good garden soil.

The *snake's head fritillary* grows in grassy water meadows in Europe. It is a beautiful plant, but is now rather rare because its habitat is under threat by drainage and cultivation. It is grown as an ornamental garden plant for its nodding flowers, which may be purple, pink or white.

The *crown imperial fritillary* grows wild from Turkey to the western Himalaya. It grows up to 1 metre high, with a spectacular cluster of yellow, red, or orange flowers near the top of the stem. It is a popular garden plant, though it has an unpleasant smell.

Fritillaries grow from bulbs, which develop under the ground. In some parts of the world, the bulbs of certain species are used as food and in the preparation of medicine. The *Kamchatka lily* or black sarana is found from East Asia and Japan to North America. It has dark coloured bulbs, which are eaten by the Innuit people of Alaska.

Scientific classification The Snake's head fritillary is *Fritillaria meleagris;* the crown imperial is *F. imperialis;* the Kamchatka lily is *F. camschatcensis.*

Fröbel, Friedrich Wilhelm August (1782-1852), was a German educator who founded the kindergarten movement. Fröbel, whose name is also spelled Froebel, started his first kindergarten in 1837. Other educators had established schools for very young children, but Fröbel was the first to use the word *kindergarten* for such schools. This word comes from two German words meaning *garden of children.* By 1900, kindergartens had spread throughout Europe, Canada, and the United States.

Fröbel designed the kindergarten to help children learn naturally. His programme included free play, games, and such activities as clay modelling, paper cutting, and weaving. Fröbel designed instructional materials that remained standard equipment in kindergartens for many years.

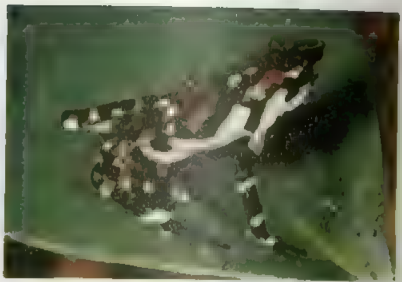
Fröbel believed in the unity of God, nature, and humanity, and this belief guided his philosophy of education. He thought education should promote the natural development of a person's spiritual being. His book *The Education of Man* (1826) explains his philosophy.

Fröbel was born in Oberweissbach, near Erfurt, Germany. He began to teach in 1805. He opened his first school, an institution for older children, in 1816.

See also **Kindergarten** (Early kindergartens).

Frobisher, Sir Martin (1535?-1594), was one of the first English navigators to search for a Northwest Passage to India and the East. He became known as one of the greatest seamen of the reign of Queen Elizabeth I. He fought against the Spanish Armada, and was knighted for his services.

His three attempts to reach Asia by sailing west extended geographical knowledge. On the first voyage in 1576, he rounded the southern end of Greenland, visited Labrador, and became the first European to sail into the bay on Baffin Island. This bay now bears his name. Frobisher took back to England rock that some people thought was gold ore. This touched off a scramble to join in his second voyage in 1577. Frobisher annexed the country to England on this trip, and returned with 180 metric tons of rock. On his third voyage, in 1578, he sailed with 15 ships and 41 miners. He entered what later became Hudson Strait, but made no further attempts at discovery. This time he brought back some 1,180 metric tons of the rock. But it proved valueless, and interest in the Northwest Passage declined. Frobisher was born in Altofts, Yorkshire, England.



Frogs differ greatly in colour and size. The spotted, brownish-green leopard frog, *above*, measures from 5 to 9 centimetres long. The colourful arrow poison frog, *top right*, grows up to 5 centimetres long. The green tree frog, *bottom right*, is less than 5 centimetres long.

Frog

Frog is a small, tailless animal with bulging eyes. Almost all frogs also have long back legs. The strong hind legs enable a frog to leap distances far greater than the length of its body. Frogs live on every continent except Antarctica. But tropical regions have the greatest number of species. Frogs are classified as *amphibians*. Most amphibians, including most frogs, spend part of their life as a water animal and part as a land animal.

Frogs are related to toads but differ from them in several ways. See the section *Kinds of frogs* in this article.

The first frogs appeared on earth about 180 million years ago. About 2,700 species of frogs and toads have developed from these early ancestors. Some species spend their entire life in or near water. Others live mainly on land and come to the water only to mate. Still other species never enter the water, not even to mate. Many frogs are climbers that dwell in trees. Others are burrowers that live underground.

Throughout history, frogs have been the source of superstitions. One old myth says that frogs fall from the sky during rain. Actually, many species that live underground leave their burrows during or after rain at the start of the mating season. Because people seldom saw these frogs during the rest of the year, they imagined the animals fell from the sky with the rain.

The body of a frog

The giant, or Goliath, frog of west-central Africa ranks as the largest frog. It measures nearly 30 centimetres long. The smallest species are only just over 1 centimetre long. Frogs also differ in colour. Most kinds are green or brown, but some have colourful markings.

Although different species may differ in size or colour, almost all frogs have the same basic body structure. They have large hind legs, short front legs, and a flat head and body with no neck. Adult frogs have no tail, though one North American species has a short, taillike structure. Most frogs have a sticky tongue attached to the front part of the mouth. They can rapidly flip out the tongue to capture prey.

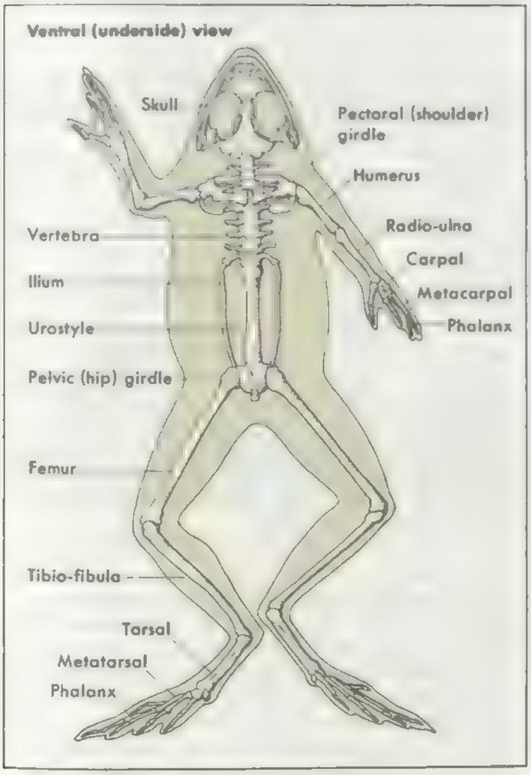
Like higher animals, frogs have such internal organs as a heart, liver, lungs, and kidneys. However, some of the internal organs differ from those of higher animals. For example, a frog's heart has three chambers instead of four. And although adult frogs breathe by means of lungs, they also breathe through their skin.

Legs. A few burrowing species have short hind legs and cannot hop. But all other frogs have long, powerful hind legs, which they use for jumping. Many frogs can leap 20 times their body length on a level surface. Frogs also use their large hind legs for swimming. Most water-dwelling species have webbed toes on their hind feet. The smaller front legs, or arms, prop a frog up when it sits. The front legs also help break the animal's fall when it jumps. Frogs that live in trees have tiny, disclike suckers on the ends of their fingers and toes. The suckers help the animal cling to the tree trunk as it climbs.

Skin. Most frogs have thin, moist skin. Many species have poison glands in their skin. The poison oozes onto the skin and helps protect the frog. If an enemy grabs a frog, the poison irritates the enemy's mouth and causes the animal to release the frog. Frogs have no hair, though the males of one African species, the so-called hairy frog, look hairy during the mating season. At that time, tiny, blood-rich growths called *papillae*, which resemble hair, grow from the sides of the frog's body. These structures provide males with extra oxygen during a period when they are very active.

Some species of frogs change their skin colour with changes in the humidity, light, and temperature. Frogs shed the outer layer of their skin many times a year.

Skeleton of a frog



Using their forelegs, they pull the old skin off over their head. They then usually eat the old skin.

Senses. Frogs have fairly good eyesight, which helps them in capturing food and avoiding enemies. A frog's eyes bulge out, enabling the animal to see in almost all directions. Frogs can close their eyes by pulling the eyeballs deeper into their sockets. This action closes the upper and lower eyelids. Most species also have a thin, partly clear inner eyelid attached to the bottom lid. This inner eyelid, called the *nictitating membrane,* can be moved upward when a frog's eyes are open. It protects the eyes without completely cutting off vision.

Most frogs have a disc of skin behind each eye. Each disc is called a *tympanum,* or eardrum. Sound waves cause the eardrums to vibrate. The vibrations travel to the inner ear, which is connected by nerves to the hearing centres of the brain.

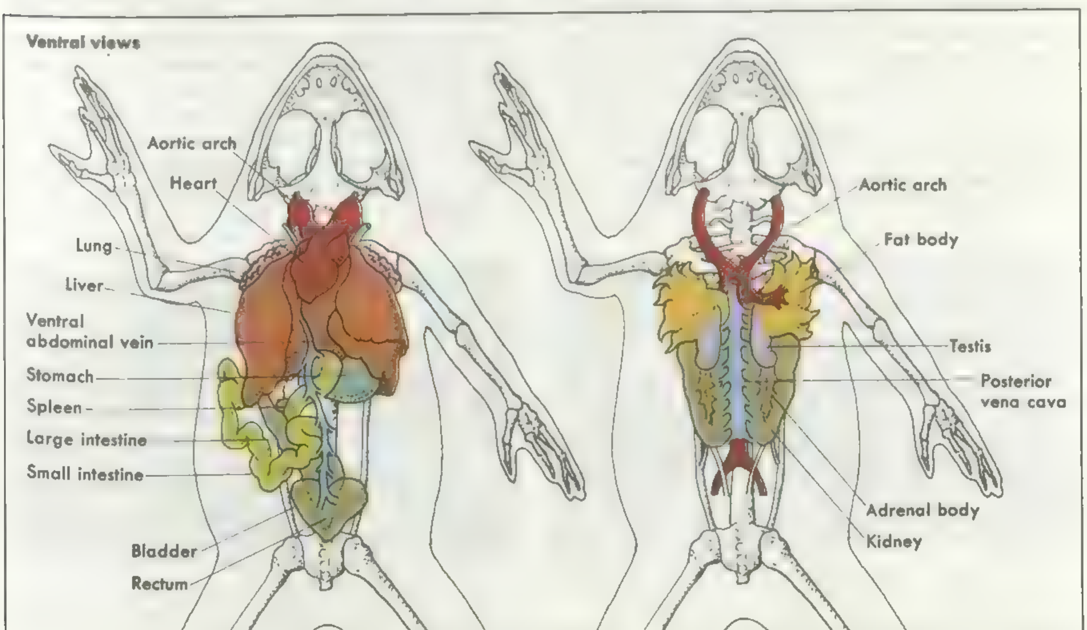
Most frogs have a delicate sense of touch. It is particularly well developed in species that live in water. The tongue and mouth have many taste buds, and frogs often spit out bad-tasting food. The sense of smell differs among species. Frogs that hunt mostly at night or that live underground have the best sense of smell.

Voice. Male frogs of most species have a voice, which they use mainly to call females during the mating season. In some species, the females also have a voice. But the female's voice is not nearly so loud as the male's.

A frog produces sound by means of its *vocal cords.* The vocal cords consist of thin bands of tissue in the *larynx* (voice box), which lies between the mouth and the lungs. When a frog forces air from its lungs, the vocal cords vibrate and give off sound.

Internal organs of a male frog

A frog's internal anatomy resembles that of higher animals in many ways. In addition, frogs are small and easily available. For these reasons, frogs have long been used for dissection in basic biology classes. The drawing on the left shows the organs that are visible when the frog's belly is cut open. The drawing on the right shows the structures behind the first layer of organs.



A male frog, *above,* sounds a mating call by puffing out its throat and forcing air over its vocal cords. It uses this call to attract a female.

A frog's sticky tongue is used to capture prey. The green frog shown on the left is about to eat a fly. The disc behind its eye is an eardrum.

In many species, the males have a *vocal sac,* which swells to a great size while a call is being made. Species that have a vocal sac produce a much louder call than do similar species that have no sac. Some species have a vocal sac on each side of the head. Others have a single sac in the throat region.

As well as a mating call, males of some species also have a territorial call. This call warns other males of the same species that a certain area is occupied and that intruders are not welcome.

The life of a frog

Frogs, like all other amphibians, are *cold-blooded*—that is, their body temperature tends to be the same as the temperature of the surrounding air or water. Frogs that live in regions with cold winters hibernate. Some species hibernate in burrows. Others spend the winter buried in mud at the bottom of a pond or stream, breathing through their skin. During hibernation, a frog lives off materials stored in its body tissues.

Mating. Most frogs that live in tropical and semitropical regions breed during the rainy season. In other regions, most species of frogs breed in spring or in early summer.

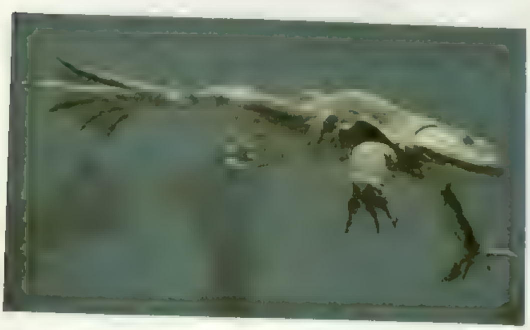
The majority of frogs, including most species that live on land, mate in water. Favoured ponds attract huge numbers of frogs year after year. This often involves long journeys, as the best ponds for hibernation (those with muddy bottoms) are not necessarily the best ones for breeding (those with a rich growth of algae). The male frogs usually enter the water first. They then call to attract mates. Their call also helps direct other males to a pool suitable for mating. Each species has its own mating call. Naturalists can identify many kinds of frogs more easily by their call than by their appearance. Female frogs respond only to the call made by males of their own species. In certain species, individual differences in the mating call may determine which male the female chooses to mate with.

After a female frog enters the water, a male grasps her and clings to her back. In this position, the male fertilizes the eggs as they leave the female's body. The eggs hatch within 3 to 25 days, depending on the species and the water temperature. Higher water temperatures speed up development, and lower temperatures slow it down. In most species, a tiny, tailed larva known as a *tadpole* hatches from the egg.

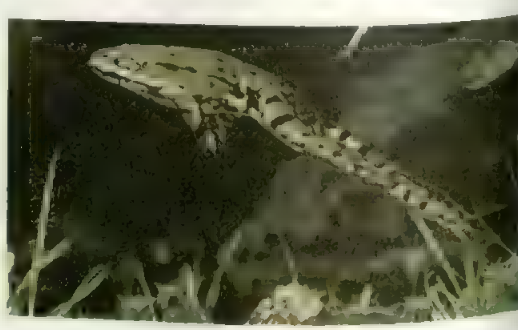
Eggs. The eggs of different species differ in size, colour, and shape. A jellylike substance covers them, providing a protective coating. This mass of eggs and jelly is called *frog spawn.*

Some species of frogs lay several thousand eggs at a time. But only a few of these eggs develop into adult frogs. Ducks, fish, insects, and other water creatures eat many of the eggs. Even if the eggs hatch, the tadpoles may be eaten by larger water animals. In addition, the pond or stream in which the eggs were laid sometimes dries up. As a result, the tadpoles die.

Certain tropical frogs lay their eggs in rain water that collects among the leaves of plants or in holes in trees. Other tropical species attach their eggs to the underside of leaves that grow over water. When the eggs hatch, the tadpoles fall into the water.



In water, a frog uses its strong hind legs for swimming. Many water-dwelling species, such as the bullfrog, *above,* have webbed toes on their hind feet as well.

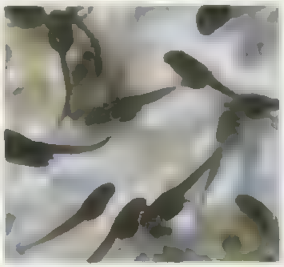


On land, the frog's muscular hind legs are used for jumping. The legs of the large edible frog, *above,* are eaten throughout Europe.

The life of a frog

A frog's life has three stages: (1) egg, (2) tadpole, and (3) adult frog. Most female frogs lay a clump of several hundred eggs in water. A male frog clings to the female's back and fertilizes the eggs as she lays them. Tiny fishlike tadpoles hatch from the eggs. As the tadpoles grow, they develop legs and a froglike body. In time, they become adult frogs and can live out of water.

Frog eggs and egg laying



Newly hatched tadpoles

Older tadpole, with legs

Frog near completion of metamorphosis

In some species, one of the parents carries the eggs until they hatch. For example, the female of certain South American tree frogs carries the eggs on her back. In another species of frog, the midwife toad, the male carries the eggs wound around his hind legs. Males of another species, Darwin's frog, carry the eggs in their vocal pouch.

Some tropical frogs lay their eggs on land. They lay them under logs or dead leaves. These frogs have no tadpole stage. A young frog hatches from the egg and begins life as a land animal.

Tadpoles are not completely developed when they hatch. At first, the tadpole clings to some support in the water, using its mouth or a tiny sucker. A tadpole has no neck, and so its head and body look like one round form. The animal has a long tail and resembles a little fish. It breathes by means of gills, which are hidden by a covering of skin.

A tadpole's form changes as the animal grows. The tail becomes larger and makes it possible for the animal to swim about and obtain food. Most tadpoles have mouth parts adapted for "grazing" the layer of algae that grows on underwater plants. Some tadpoles eat frog eggs and other tadpoles.

In time, the tadpole begins to grow legs. The hind legs appear first. Then the lungs begin to develop and the front legs appear. The digestive system changes, enabling the frog that develops to eat live animals. Just before its *metamorphosis* (change) into a frog, the tadpole loses its gills. Finally, a tiny frog, still bearing a stump of a tail, emerges from the water. Eventually, the animal absorbs its tail and assumes its adult form.

Some tadpoles are so small they can hardly be seen. But a fully developed bullfrog tadpole may measure nearly 18 centimetres long. It may take two or three years for a bullfrog tadpole to develop into a frog. But in most species, the tadpoles change into adults within a few months. In a few species that breed in temporary ponds, this process may take less than two weeks.

Adult frogs. After a frog becomes an adult, it may take a few months to a few years before the animal is mature enough to breed. In captivity, a bullfrog may live more than 15 years. But few species of frogs live longer than 6 to 8 years in the wild. Many are eaten by such enemies as bats, herons, otters, raccoons, snakes, turtles, and fish.

Adult frogs eat mainly insects and other small animals, including earthworms, minnows, and spiders. Most frogs use their sticky tongue to capture prey. The tongue is flipped out of the mouth in response to movement by the prey.

Most frogs have teeth only on their upper jaw. Toads lack teeth altogether. As a result, frogs and toads swallow their prey in one piece. To aid in the swallowing process, the frog's eyes sink through openings in the skull and force the food down the throat so that it can be digested.

Kinds of frogs

Frogs and toads make up the order Anura, or Salientia, one of the three main groups of amphibians. Most zoologists divide this order into at least 19 families of living frogs and toads.

One family of anurans consists of *true frogs*. *True toads* make up another family. They are found in all parts of the world except Antarctica. Most true toads have a broader, flatter body and darker, drier skin than do most true frogs. True toads are commonly covered with warts, but true frogs have smooth skin. Unlike most true frogs, the majority of true toads live on land. The adults go to water only to breed. For more information on true toads, see **Toad**.

Of the other families in the order Anura, some closely resemble true frogs, and others closely resemble true toads. Still others have features of both true frogs and true toads. Certain anuran families other than the true toads also have the word *toad* as part of their common name.

True frogs are most common in Africa. The majority live in or near water. They have long hind legs, smooth skin, a narrow waist, and webbed hind feet.

There are nearly 700 species of true frogs worldwide. Species such as the European common frog, the edible frog, the North American bullfrog and the leopard frog are the ones most likely to be found in ponds and ditches. This family also includes the Goliath frog, which is the world's largest. These frogs produce masses of spawn every spring.

Tree frogs, like true frogs, live on all continents except Antarctica. Most tree frogs measure less than 5 centimetres long and dwell in trees. Their bodies are flattened and slender. Tree frogs have disclike suckers on their toes, which help them cling to tree trunks. Many tree frogs are green or brown, enabling them to blend with the bushes and trees. The largest number of species are to be found in Central and South America. Some are *marsupials*—the females carry not only the eggs but also the tadpoles in pouches or depressions on their backs. Several Australian species are able to tolerate drought. Old World species include the Javan gliding frog, which has fringed limbs and extensively webbed feet. These features enable it to glide from tree to tree in a similar way to the flying squirrel.

Other frogs include Leptodactylid frogs, Myobatrachid frogs, poison dart frogs, narrow-mouthed toads, spadefoot toads, and tailed frogs.

Leptodactylid frogs make up a large family of frogs that live mainly in South America. Their name means "light-fingered" and refers to their weakly-developed webs and lack of suckers. The barking frog and the cliff frog live on rocky cliffs in Texas, U.S.A. These frogs lay their eggs under rocks. Tiny frogs hatch from the eggs, without going through the tadpole stage. Many species lay eggs in a hole near water. The female beats the egg jelly into a foam, in which the tadpoles live until rain washes them into the nearby water.

Myobatrachid frogs, also called *southern frogs,* live only in Australia and New Guinea. Most are burrowing types. Some live in fast-flowing streams. One of the best known species is the black and yellow corroboree frog, from the alpine regions of Southeastern Australia. Many species have well-developed poison glands.

Poison dart frogs comprise over 100 species. They are famous for their brilliant colours, and the skin toxins they produce. The Indians of tropical America use these toxins to poison arrowheads.

Narrow-mouthed toads live throughout most tropical and subtropical regions. They are most abundant in New Guinea. As their name suggests, these frogs have an extremely narrow mouth. Most species live in burrows or amongst leaf litter.

Spadefoot toads live in Asia, Europe, North America, and northwestern Africa. They are so named because most of them have a sharp-edged spadelike growth on each hind foot. They use this growth as a digging tool.

Spadefoot toads dwell underground and are usually seen only after rain. Several North American species live in dry regions of U.S. Great Plains and Southwest. They may remain in their burrows for weeks at a time to stay moist. They breed following heavy rains, often laying their eggs in temporary ponds. The tadpoles develop rapidly. If enough food is available, tiny adults may emerge in only 12 days. The European spadefoot is known as the "garlic frog" because of its smell.

Tailed frogs comprise the oldest surviving group of frogs. Three species that live in New Zealand have retained the muscles that were once used to control a tail. A fourth species has retained the whole taillike appendage. This frog lives in swift mountain streams of the northwestern United States and southwestern Canada. The moving water makes external fertilization of the eggs difficult. Instead, the male uses a taillike structure to fertilize the eggs while they are still inside the female. Tadpoles of tailed frogs have a large sucker that enables them to hold on to rocks even in the strongest current.

Frogs and human beings

Frogs benefit us in many ways. They eat large numbers of insects, which might otherwise become serious pests. Frogs also provide us with food. The meaty hind legs of larger frogs are considered a delicacy in many countries. Frogs also are used widely in the laboratory. Medical researchers use frogs to test new drugs, and students dissect frogs to learn about anatomy.

Human beings are, in fact, the frog's worst enemy. People obtain most of the frogs used for food and in the laboratory from the wild. Furthermore, people destroy the homes and breeding places of frogs by replacing natural areas with cities and farms. They also pollute and so poison the waters in which frogs dwell.

Scientific classification. True frogs make up the family Ranidae. Tree frogs make up the family Hylidae; Leptodactylid frogs, the family Leptodactylidae; Myobatrachid frogs, the family Myobatrachidae; poison dart frogs, the family Dendrobatidae; narrow-mouthed toads, the family Microhylidae; and spadefoot toads, the family Pelobatidae. Tailed frogs belong to the family Leiopelmatidae.

Related articles in *World Book* include:

Amphibian
Bullfrog
Ear (The ears of animals)
Metamorphosis (picture: Metamorphosis of a frog)
Tadpole
Toad
Tree frog

Outline

I. The body of a frog
- A. Legs
- B. Skin
- C. Senses
- D. Voice

II. The life of a frog
- A. Mating
- B. Eggs
- C. Tadpoles
- D. Adult frogs

III. Kinds of frogs
- A. True frogs
- B. Tree frogs
- C. Other frogs

IV. Frogs and human beings

Questions

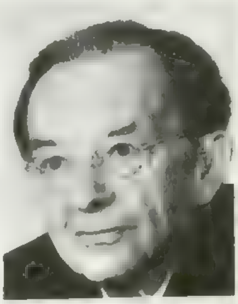
How many species of frogs are there?
Which is the world's largest frog?
How do tadpoles breathe? How do adult frogs?
In what ways do frogs benefit us?
What do tadpoles eat? What do adult frogs eat?
How did spadefoot toads get their name?
Why are some frogs able to climb trees?
What is the function of a male frog's territorial call?
What are some of the changes a tadpole undergoes during its metamorphosis into a frog?
What is the function of the *nictitating membrane*?

Froissart, Jean (1337?-1410?), a French poet and historian, wrote *The Chronicles of France, England, Scotland, and Spain.* This four-volume work describes events from 1325 to 1400, especially the Hundred Years' War (see **Hundred Years' War**). *The Chronicles* are based partly on what Froissart actually witnessed and partly on research. His history is not always accurate, but he described vividly the manners and personalities of the times. One critic said, "Froissart's whole business was to live in the fourteenth century, and tell us what he saw there." William Morris and other writers of the 1800's drew materials for some of their narrative poems from *The Chronicles.* Froissart also wrote of his school days and early love affairs in "L'Espinette Amoureuse."

During the 1360's, Froissart served five years as secretary to Queen Philippa of England. He studied to be a priest, but preferred writing of chivalry and adventure. Froissart was born in Valenciennes, France.

Fromm, Erich (1900-1980), was a German-born social psychoanalyst. He became a leading supporter of the idea that most human behaviour is a learned response to social conditions. In adopting this concept, Fromm rejected much of the theory of the noted Austrian psychiatrist Sigmund Freud. Freud maintained that instincts determine most human behaviour.

Fromm applied the ideas of sociology to psychoanalysis. He studied the social and cultural processes by which people come to learn and act out the behaviour expected of them by their society.



Erich Fromm

Fromm wrote numerous books that reflect his many fields of interest, such as philosophy, psychology, religion, and sociology. His major works include *The Sane Society* (1955), *The Art of Loving* (1956), and *The Heart of Man* (1964).

Fromm was born in Frankfurt. He gained his Ph.D. degree from the University of Heidelberg in 1922. In 1933, Fromm went to the United States to lecture at the Institute for Psychoanalysis in Chicago. He became a United States citizen in 1940. Fromm held various positions in psychoanalytical institutions in the United States and taught at universities in the United States and Mexico.

Frond. See **Fern.**

Fronde was a revolt of nobles against the French monarchy. The word means *sling,* a popular game among French boys. Historians do not know how the revolt got its name. In 1648, the Parlement of Paris rebelled against French tax policies. The Prince of Condé led armies that crushed the rebellion in 1649. Condé himself then led a new revolt in 1650. It failed in 1652, and the monarchy became stronger than it had been before the revolt occurred.

Front. See **Weather** (Fronts; illustrations).

Frontal bone. See **Head.**

Frontenac, Comte de (1620-1698), was governor general of New France, the French empire in North America, in the late 1600's. He helped establish France's power in North America so firmly that it lasted for more than 50 years after his death.

Frontenac was appointed governor general in 1672. His stern, military ways and hot temper often got him into trouble with the civil authorities in New France. But Frontenac knew when to be tactful and when to be masterful with the Indians. The colony prospered under his rule.

Frontenac encouraged exploration of the west, and aided the expeditions of Robert Cavelier, Sieur de la Salle; Louis Jolliet; and Father Marquette. But he quarrelled constantly with Bishop Laval and the priests, mainly about using brandy in the Indian trade. The church objected to this. He was recalled to France in 1682.

Seven years later, however, he was again appointed governor general, as New France needed his stern rule. The French planned to drive the English out of North America, or hold them in a narrow strip of land along the Atlantic. Frontenac began campaigns against the Iroquois Indians, whom the English encouraged in their attacks on New France. Warfare followed on the New York and New England frontiers. Frontenac's bands of French fighters and Algonquian Indians were not able to make permanent conquests. In 1690, Frontenac defended Quebec against an attacking English fleet. Six years later, Frontenac's forces laid waste the villages and lands of the Iroquois. The Treaty of Ryswick, in 1697, stopped the war for a time. Frontenac died less than a year later.

Detail of a watercolour by J. H. de Rinzy

The Comte de Frontenac served two terms as governor general of New France during the late 1600's. This water colour shows Frontenac, seated in a canoe, on his way to Fort Cataraqui, which he built on Lake Ontario in 1673.

Frontenac was born at Saint-Germain-en-Laye, near Paris. He became a soldier as a boy, and was made a brigadier general at the age of 26. He served in Flanders, Germany, Italy, Hungary, and Crete before he became governor general of New France. His given and family name was Louis de Buade.

See also **Canada, History of.**

Frost is a pattern of ice crystals formed from water vapour on grass, windowpanes, and other exposed surfaces near the ground. Frost occurs mainly on cold, cloudless nights when the air temperature drops below 0° C, which is the freezing point of water.

Frost and dew form in much the same way. During the day, the earth's surface absorbs heat from the sun. When the sun sets, the earth begins to cool. The drop in temperature is greater on clear nights than on cloudy nights because there are no clouds to reflect the heat given off from the earth's surface. As the cooling continues, the water vapour in the air condenses to form dewdrops on objects. Some of these dewdrops freeze when the temperature falls below 0° C. The frozen droplets increase in size, becoming frost crystals when the surrounding dewdrops evaporate and deposit water vapour on the crystals.

At temperatures below freezing, water vapour sometimes changes directly into ice crystals without first forming dewdrops.

Frost crystals, also called *hoarfrost,* occur in two basic forms—platelike and columnar. The *platelike* crystals are flat and resemble snow crystals. The *columnar* crystals are six-sided, hollow columns of ice.

The term *frost* also refers to below-freezing temperatures harmful to plants. At such temperatures, the fluids in plant cells freeze and expand, causing the cell walls to rupture. Farmers protect their crops from this type of killing frost by warming cold surface air with oil-burning heaters. They also use large fans to mix the surface air with the warmer air above it. Artificial fog may also be made to reduce the loss of heat from the surface.

Frost, John (1784?-1877), a British radical, led the Chartist Movement in Wales. He worked as a tailor and draper in Newport, Gwent, and became active in the struggle for political reform. In 1836, Frost served as mayor of Newport. Frost became a recognized national leader of the Chartists in 1839. On November 4 of that year, Frost led an armed force

John Frost

Platelike frost crystals are flat and closely resemble snow crystals. Frost crystals of this type commonly form delicate, lacy patterns on windowpanes, *above.*

Columnar frost crystals are six-sided, hollow columns of ice. They may resemble thick needles when they grow on such exposed objects as blades of grass or leaves of plants, *above.*

of workers into Newport and attacked the Westgate Hotel. Troops who were occupying the hotel easily defeated Frost's force, killing 20 of them and wounding many more. After their trial, Frost and his associates were transported to Tasmania, Australia. Frost later returned to Britain. He died near Bristol.

Frost, Robert Lee (1874-1963), became the most popular American poet of his time. He won the Pulitzer Prize for poetry in 1924, 1931, 1937, and 1943. In 1960, the U.S. Congress voted Frost a gold medal "in recognition of his poetry, which has enriched the culture of the United States and the philosophy of the world." Frost's public career reached a climax in January 1961, when he read his poem "The Gift Outright" at the inauguration of President John F. Kennedy.

His life. Frost was born in San Francisco, California, U.S.A., on March 26, 1874. After the death of his father in 1885, his family moved back to New England (the northeastern region of the United States), the original family home. Frost attended schools in Lawrence, Massachusetts, and later briefly attended Dartmouth and Harvard colleges. In the early 1890's, he worked in New England as a farmer, an editor, and a schoolteacher, absorbing the materials that were to form the themes of many of his most famous poems. His first volume of poetry, *A Boy's Will,* appeared in 1913. His final collection, *In the Clearing,* appeared in 1962. Frost died on Jan. 29, 1963.

His poems. Frost's poetry is identified with New England, particularly the states of Vermont and New Hampshire. Frost found inspiration for many of his finest poems in the region's landscapes, folkways, and speech mannerisms. His poetry is noted for its plain language, conventional forms, and graceful style. Many of his earliest poems are as richly developed as his later ones.

Frost is sometimes praised for being a direct and straightforward writer. While he is never obscure, he cannot always be read easily. His effects, even at their simplest, depend upon a certain slyness for which the reader must be prepared. In "Precaution," Frost wrote:

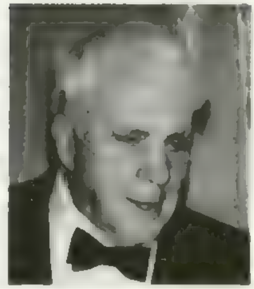
> I never dared be radical when young
> For fear it would make me conservative
> When old.

In his longer, more elaborate poems, Frost writes about complex subjects in a complex style.

Frost tends to restrict himself to New England scenes, but the range of moods in his poetry is rich and varied. He assumes the role of a puckish, homespun philosopher in "Mending Wall." In such poems as "Design" and "Bereft," he responds to the terror and tragedy of life. He writes soberly of vaguely threatening aspects of nature in "Come In" and "Stopping by Woods on a Snowy Evening." In the latter poem, he wrote:

> My little horse must think it queer
> To stop without a farmhouse near
> Between the woods and frozen lake
> The darkest evening of the year.

A similar varied pattern can be found in Frost's character studies. "The Witch of Coos" is a comic account of the superstitions of rural New England. In "Home Burial," this same setting is the background of tragedy centring around a child's death. In "The Hill Wife," Frost shows the loneliness of a rural existence driving a person insane.



Robert Frost

By placing people and nature side by side, Frost often appears to write the kind of romantic poetry associated with England and the United States in the 1800's. There is, however, a crucial difference between his themes and those of the older tradition. The romantic poets of the 1800's believed people could live in harmony with nature. To Frost, the purposes of people and nature are never the same, and so nature's meanings can never be known. Probing for nature's secrets is futile and foolish. Humanity's best chance for serenity does not come from understanding the natural environment. Serenity comes from working usefully and productively amid the external forces of nature. Frost often used the theme of "significant toil"—toil by which people are nourished and sustained. This theme appears in such famous lyrics as "Birches," "After Apple-Picking," and "Two Tramps in Mud Time."

Frostbite is an injury that results from exposure of the body to extreme cold. Frostbite occurs when ice crystals form in the skin and—in more severe cases—in the tissues beneath the skin. Frostbite most commonly affects the ears, nose, hands, and feet. A frostbitten area may turn red or unnaturally white. Early symptoms include feelings of coldness, tingling, pain, and numbness.

Frostbite should be treated by restoring circulation and warmth to the affected part. Rubbing frostbite with snow or ice is dangerous because it might remove skin and damage the tissues. It is safest to warm the frostbitten part rapidly in tepid water. The water temperature should be between 39° and 41° C. Intense pain may occur during the rapid rewarming. The victim should be kept in a warm room, with the affected part slightly raised. If frostbite is not treated quickly, *gangrene* (tissue death) may develop. Healed tissue may show such long-term complications as increased sensitivity to cold and disturbances of sensation.

See also **Chilblain; First aid** (Frostbite).

Frozen food. See Food, Frozen.

Fructose is a sugar produced by nearly all fruits and by many vegetables. Fructose, also known as *fruit sugar,* is nearly twice as sweet as *sucrose* (household sugar). Fructose is used to sweeten such food products as diet foods, gelatin desserts, jams, jellies, soft drinks, and syrups. It is the chief sweetener in honey.

Foods that contain fructose taste as sweet as similar foods made with sucrose, but they may have fewer calories. Fructose gives ice cream and sweets a smooth texture. It also absorbs moisture readily and so helps keep baked goods from becoming stale.

Fructose is produced commercially as a liquid, powder, or tablet. Food processors use fructose primarily in the form of syrup prepared from maize.

See also **Corn syrup; Sugar** (Kinds of sugar).

Fruit is the part of a flowering plant that contains the plant's seeds. Fruits include acorns, cucumbers, tomatoes, and wheat grains. However, the word *fruit* commonly refers to the juicy, sweet or tart kinds that people enjoy as desserts or snacks. The word comes from the Latin word *frui,* meaning *enjoy.* Popular fruits include apples, bananas, grapes, oranges, peaches, pears, and strawberries.

Many fruits are nutritious as well as appetizing. For example, oranges and strawberries contain large amounts of vitamin C. Most fruits have a high sugar content, and so they provide a rapid source of energy. Fruits alone cannot provide a balanced diet, however, because, for example, the majority of them supply little protein.

The world's fruit growers raise millions of tons of fruit annually. Fruit growing is a branch of *horticulture,* a field of agriculture that also includes the growing of nuts, vegetables, flowers, shrubs and grasses. Most nuts are actually fruits, as are cucumbers, green peppers, and tomatoes.

To prevent confusion, horticultural scientists define a fruit as an edible seed-bearing structure that (1) consists of fleshy tissue and (2) is produced by a *perennial.* A perennial is a plant that lives for more than two years without being replanted. The horticultural definition of a fruit excludes nuts and vegetables. Nuts are firm rather than fleshy. Most vegetables are *annuals*—that is, the plants live for only one season.

In some cases, the horticultural definition of a fruit conflicts with the definition used by botanists and with common usage. For example, watermelons and muskmelons are fruits, and most people regard them as such. But they grow on vines that must be replanted annually, and so horticulturists regard melons as vegetables. Rhubarb is sometimes considered a fruit. But people eat the leafstalk of the rhubarb plant, not the seed-bearing structure. Therefore, horticulturists classify rhubarb as a vegetable.

This article discusses fruits chiefly from a horticultural point of view. The last section discusses fruits from a botanical viewpoint.

How horticulturists classify fruits

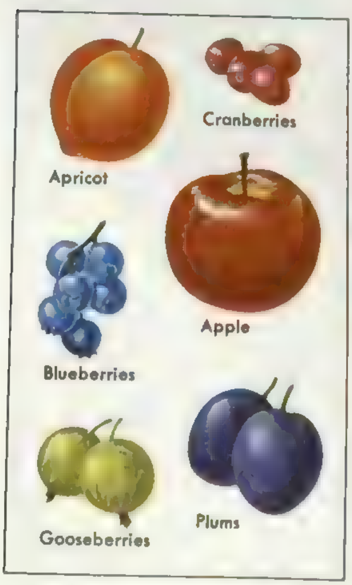
Many of the fruits cultivated today have spread a long distance from the regions of their natural habitat. Apples, cherries, and pears originated in Europe and western Asia. Apricots and peaches first came from China, and lemons and oranges from China and Southeast Asia. All these fruits are now grown in any part of the world that has a favourable climate.

All fruits need at least some moisture, and most require considerable amounts. Dates and olives are among the few fruits that can be grown in dry regions without irrigation.

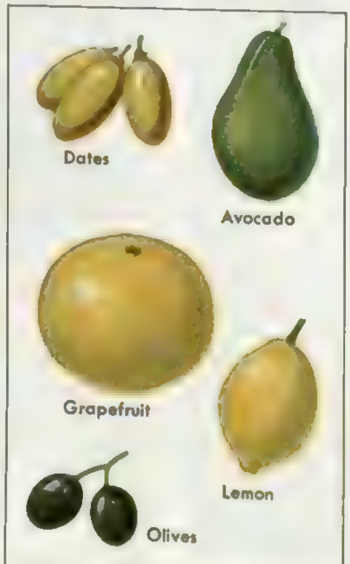
Horticulturists classify fruits into three groups, based on temperature requirements for growth: (1) temperate fruits, (2) subtropical fruits, and (3) tropical fruits.

How horticulturists classify fruits

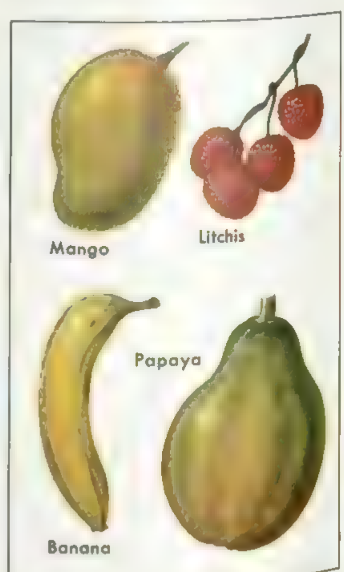
Any seed-bearing structure produced by a flowering plant is a fruit. But the word *fruit* has a more limited meaning in common usage and in horticulture, the branch of agriculture that includes fruit growing. Thus, the word usually refers to the edible sweet or tart fruits that are popular foods and widely grown farm crops. Horticulturists classify these fruits into three groups, based on temperature requirements for growth: (1) temperate fruits, (2) subtropical fruits, and (3) tropical fruits. Some examples of each of these types are shown below.



Temperate fruits must have an annual cold season. They are grown mainly in the Temperate Zones, the regions between the tropics and the polar areas.



Subtropical fruits need warm or mild temperatures throughout the year but can survive occasional light frosts. They are grown chiefly in subtropical regions.



Tropical fruits cannot withstand frost. They are grown mainly in the tropics. Large amounts of some species, especially bananas and pineapples, are exported.

Temperate fruits must have an annual cold season to grow properly. They are grown chiefly in the Temperate Zones, the regions between the tropics and the polar areas. Most temperate fruits come from Europe and North America, but Asia and Australia are also major producing areas.

The principal temperate fruits are apples, apricots, cherries, peaches, pears, and plums. In addition, most *small fruits,* which grow on plants smaller than trees, are raised mainly in the Temperate Zones. They include blueberries, cranberries, gooseberries, grapes, kiwi fruit, raspberries, and strawberries.

Subtropical fruits require warm or mild temperatures throughout the year but can survive an occasional light frost. They are grown chiefly in subtropical regions.

The most widely grown subtropical fruits are the citrus group, which includes grapefruit, lemons, limes, and oranges. Oranges, the leading citrus crop, are grown throughout the subtropics, from southern Japan to southern Europe. Florida, in the United States, and Spain produce large quantities of oranges. Citrus crops are also raised on some farms in the tropics, but the somewhat cooler climate of the subtropics produces better-tasting and more attractive fruit. Other subtropical fruits include dates, figs, olives, persimmon, pomegranates, and certain types of avocados.

Tropical fruits are grown mainly in the tropics and cannot withstand even a light frost. Bananas and pineapples, the best-known tropical fruits, are grown throughout the tropics, and much of each crop is exported. The majority of other tropical fruits are usually consumed locally. They include acerolas, breadfruits, cherimoyas, guavas, litchis, mangoes, mangosteens, papayas, and soursop.

Growing fruit

Almost all species of fruits grow on plants that have a woody stem. Such plants are trees, bushes, or woody vines. Fruits that grow on trees include apples, cherries, lemons, limes, oranges, and peaches. Most small fruits grow on bushes, but grapes and kiwi fruit are borne on vines. Bananas and strawberries grow on plants that have a soft, rather than a woody, stem.

Fruit crops, unlike most other crops, are not grown from seeds. Plants grown from seeds may differ in many ways from generation to generation. But growers strive to produce plants that will bear fruits of uniform type, appearance, and quality. Such fruits bring the highest prices when marketed. Fruit plants produce fruits of uniform quality if grown *vegetatively*—that is, from certain parts of desirable plants, such as stems, buds, and roots. The part that is grown develops new tissues and new parts identical to those of the parent plant.

Fruit plants are produced vegetatively in three main ways: (1) by grafting, (2) from cuttings, and (3) from specialized plant structures. Most fruit trees are reproduced by grafting. In this process, a bud or piece of stem from one tree is joined to a *rootstock* from another. A rootstock is a root or a root plus its stem. The resulting tree will have mostly the same characteristics as the tree from which the bud or stem was taken. However, the rootstock may determine such characteristics as the size and productivity of the new tree.

Some fruit plants are produced from *cuttings* or from specialized structures. Most cuttings are pieces of stem that grow roots when placed in water or moist soil. Specialized structures called *runners* are used to grow strawberry plants. Runners are long, slender shoots that mature strawberry plants send out along the ground. A runner placed in soil develops into a new plant.

Some fruit growers produce their own plants from grafts, cuttings, or specialized structures. But most growers buy plants from nurseries.

The branch of horticulture that deals with fruit growing is called *pomology.* Pomologists have developed highly efficient methods of planting and caring for fruit crops, and most fruit farms use these techniques.

There are three main steps in growing fruit: (1) planting, (2) caring for the crop, and (3) harvesting.

Planting. Fruit crops are perennials, and so they do not have to be replanted annually as do most other crops. After the original planting, a fruit farmer need replace only those plants that have become unproductive. Many fruit plants remain productive for 30 to 50 years or even longer. In mild climates, farmers generally plant trees, bushes, and vines in autumn. In cold climates, planting usually takes place in spring.

Most bushes are planted from about 1 to 1.5 metres apart in rows that are about 2 to 3 metres apart. Rows of grapevines are spaced about 3 metres apart. In the past, farmers almost always grew full-sized fruit trees. In most cases, the trees were planted from about 6 to 12 metres apart to allow room for growth. Today, many farmers prefer to grow dwarf trees, which are planted closer together. The branches of each tree may grow up a supporting framework called a *trellis.* The trellis enables all the fruit to receive the maximum amount of sunlight, and so the crop ripens better and faster than it otherwise would. Fruit is also easier to harvest from dwarf trees than from full-sized trees.

Caring for the crop. Most fruit growers use special machinery to fertilize, cultivate, and otherwise care for their crops. Fruit crops must be fertilized at least once a year. Some fertilizers are applied to the soil, and others are sprayed onto the plants. Many fruit growers cultivate the soil around young fruit plants periodically. This practice helps control weeds and thus encourages the growth of the crop. Most fruit crops grown in extremely dry regions must be irrigated. Farmers use various methods, such as ditches and sprinklers, to distribute irrigation water.

In many cases, the branches of a young fruit tree must be *trained* so that the tree develops a uniform shape and a sturdy structure. Training may involve propping up the trunk or tying the branches, or it may consist entirely of pruning. Pruning strengthens a plant by ridding it of unproductive branches. Nearly all fruit plants have to be pruned at least once annually. In addition, most fruit farmers remove some of the crop from the trees during the early stages of the fruit's growth. This practice, called *thinning,* helps enlarge the remaining fruit.

The majority of fruit growers use chemical pesticides to protect their crops against diseases and insect pests. Most pesticides are sprayed or dusted onto crops by tractor-driven machinery or specially equipped light aeroplanes or helicopters. Plant breeders have also developed varieties of fruit plants that resist certain diseases and harmful insects.

A mechanical cherry picker shakes a cherry tree to loosen the fruit. The cherries drop onto outstretched cloths, roll onto a conveyor, and are deposited in a tank of salt water. The fruit floats in the water and thus is protected from being bruised.

Sudden spring frosts can endanger fruit crops in temperate or subtropical regions. Farmers use water distributed by sprinklers to protect small-fruit crops from frosts. Water releases heat as it freezes. If it is sprinkled onto the crops continuously, it keeps the tender flowers and young fruits from freezing. Farmers use heaters to protect tree crops from spring frosts.

Harvesting. Fruits are bruised more easily than most other crops, and so they must be harvested with greater care. Most are picked by hand. However, the increasing cost of hand labour has encouraged the use of fruit-harvesting machines. Some of these machines have arms that shake the fruit loose from the plants. The loosened fruit then drops onto outstretched cloths. Other mechanical fruit pickers have fingers that "comb" the fruit from the plants.

Marketing fruit

Brazil is the leading fruit producing country in the world. Of the 330 million metric tons of fruit produced globally in 1988, Brazil yielded 28 million metric tons. Brazil was responsible for 30 per cent of the world's orange production and more than 12 per cent of the world's banana production. The United States, with a total production of 26 million metric tons of fruit, was the next largest producer in 1988. The United States provides 52 per cent of the world's grapefruit supply.

Most fruit scheduled to be sold fresh is taken from the orchard or field by truck and delivered to a packing house. Many large fruit farms have their own packing facilities. Commercial packing houses are centrally located in fruit-growing regions. Most large packing houses are fully mechanized. Machines wash the fruit, sort it according to size and quality, and pack each batch into containers. The fruit is then shipped to market or stored for future delivery. Railways and trucks carry most overland shipments of fruit. Most overseas shipments travel by ocean freighter.

Fruits can be stored for varying lengths of time under controlled conditions. Temperate tree fruits must be stored at temperatures around freezing point. Some kinds of apples can be kept fresh for about a year under such conditions. On the other hand, most small fruits remain fresh for only a few days or weeks in cold storage. Tropical and subtropical fruits can be stored for a few weeks or months under temperature-controlled conditions. The temperatures, though cool, must be well above freezing. The amount of oxygen ordinarily present in the air promotes spoilage of fruit. The storage time for all fruits can be lengthened by reducing the oxygen supply.

Much fruit is shipped directly from farms to food processors. Processing plants preserve fruit by such methods as canning, drying, and freezing. See **Food, Frozen; Food preservation.**

Developing new varieties of fruit

Occasionally, an individual plant develops an unexpected characteristic. For example, a fruit tree may suddenly start to bear fruit of a different colour. Such a plant is called a *sport.* Growers have used sports to develop many new cultivated varieties of fruit. Cultivated varieties are also known as *cultivars.* The trees of Delicious apples originally produced only pale-coloured, striped fruit. Then, some of the branches on individual trees began to bear solid-red apples. By grafting these branches onto appropriate rootstocks, growers produced the attractively coloured varieties of Delicious apples available today.

Sports often play an important role in the development of new varieties of fruit. But the majority of new varieties are produced by a process called *selection.* In selection, plants grown from seed are examined for various desirable qualities. An individual plant may thus be singled out for high productivity or for the superior colour, texture, or flavour of its fruit. By reproducing this plant vegetatively, the desirable characteristic is preserved from one generation to the next. If the characteristic persists, the fruit may be classed as a new variety.

In addition to selection, modern fruit growers also use a technique called *crossing* or *hybridization.* In this process, pollen is taken from a plant that has been selected for a particular desirable trait. The pollen is placed in the flower of a plant selected for another desirable quality. Some of the plants grown from the resulting seed may have the desirable characteristics of both parents. Occasionally, one of these plants may prove worthy of being classed as a new variety. In most cases, however, the entire process of selection and hybridization must be repeated many times to produce a new variety. Hybridization is a highly useful technique because it enables growers to produce varieties with more and more desirable qualities.

How botanists classify fruits

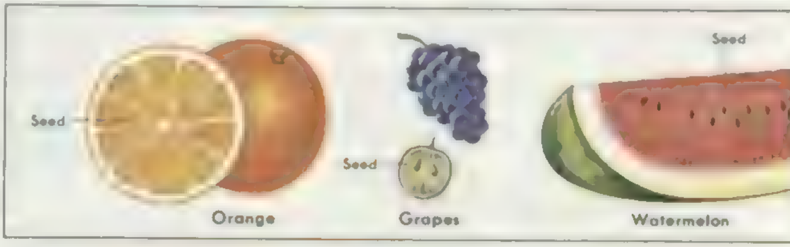
Fruit, the seed-bearing structure of a flowering plant, develops from the *ovaries* of the flowers. An ovary is a hollow structure near the base of a flower. It may hold one seed or more than one, depending on the species of the plant. See **Tree** (diagram: How most trees reproduce [Fruit-bearing trees]).

The wall of an ovary of mature fruit, in which the seed is fully developed, has three layers. The outer layer is called the *exocarp,* the middle layer is known as the *mesocarp,* and the inner layer is the *endocarp.* The three layers together are called the *pericarp.*

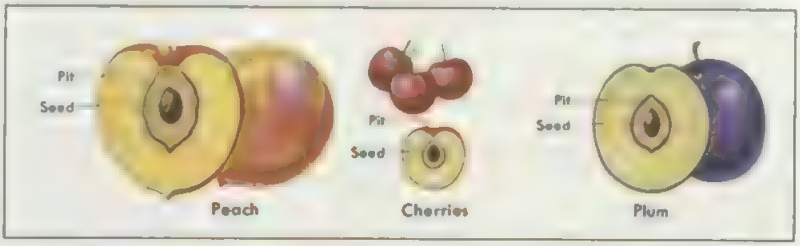
Simple fruits

Simple fruits are classified into two main groups, depending on whether their tissue is fleshy or dry. Fleshy simple fruits include most of the seed-bearing structures that are commonly called fruits. They are divided into three main types (1) berries, (2) drupes, and (3) pomes. The drawings below show some examples of each of these types and of several dry simple fruits.

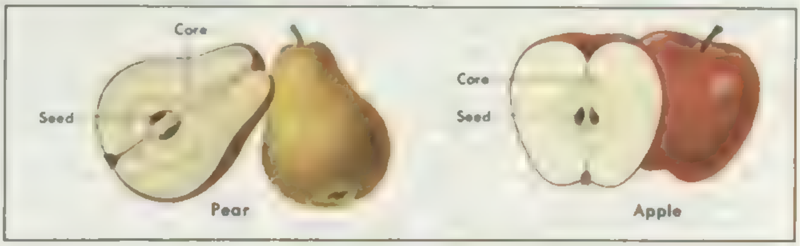
Berries consist entirely of fleshy tissue, and most species have many seeds. The seeds are embedded in the flesh. This group includes only a few of the fruits that are commonly known as berries.



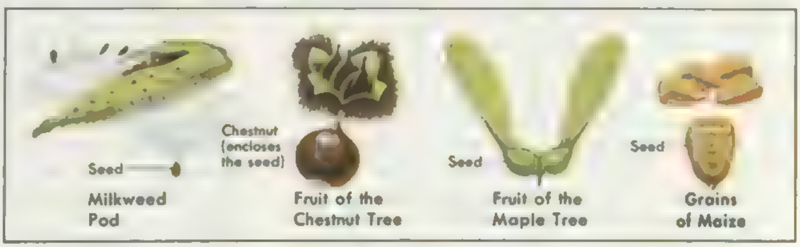
Drupes are fleshy fruits that have a hard inner stone or pit and a single seed. The pit encloses the seed.



Pomes have a fleshy outer layer, a paperlike core, and more than one seed. The seeds are enclosed in the core.

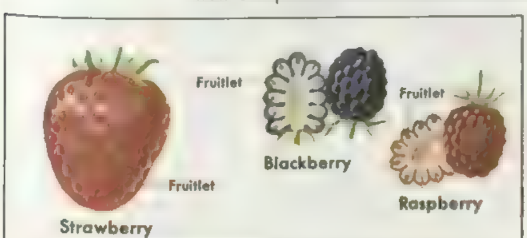


Dry simple fruits are produced by many kinds of trees, shrubs, garden plants, and weeds. The seed-bearing structures of nearly all members of the grass family, including maize and wheat, belong to this group.

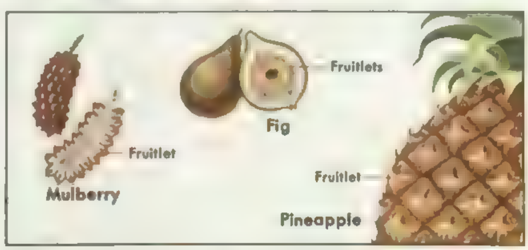


Compound fruits

A compound fruit consists of a cluster of seed-bearing structures, each of which is a complete fruit. Compound fruits are divided into two groups, (1) aggregate fruits and (2) multiple fruits.



Aggregate fruits include most of the fruits that are commonly called berries. Each fruitlet of a blackberry or a raspberry is a small drupe. Each "seed" of a strawberry is a dry fruitlet.



Multiple fruits include mulberries, figs, and pineapples. Mulberry fruitlets are small drupes. Each "seed" in a fig and each segment of a pineapple is a fruitlet.

Botanists classify fruits into two main groups: (1) simple fruits and (2) compound fruits. A simple fruit develops from a single ovary, and a compound fruit develops from two or more ovaries.

Simple fruits are by far the largest group of fruits. They are divided into two types, depending on whether their pericarp is fleshy or dry.

Fleshy simple fruits include most of the seed-bearing structures that are commonly called fruits. There are three main kinds of these fruits: (1) berries, (2) drupes, and (3) pomes.

Berries have an entirely fleshy pericarp. Botanists classify bananas, blueberries, grapes, green peppers, muskmelons, oranges, tomatoes, and watermelons as berries. Some berries, including watermelons and muskmelons, have a hard rind. Fruits of this kind are called *pepos.* Other berries, including the citrus fruits, have a leathery rind. They are called *hesperidiums.* Raspberries, strawberries, and most of the other fruits that are commonly known as berries are actually compound fruits.

Drupes have an exocarp that forms a thin skin. The endocarp develops into a stone or pit, and only the mesocarp is fleshy. Such fruits include apricots, cherries, peaches, and plums.

Pomes are fleshy fruits with a paperlike core. Apples and pears are pomes.

Dry simple fruits include the pods of the bean plant, the milkweed, the pea plant, and the locust tree; the grains of the maize, rice, and wheat plants; and nuts. Botanists regard nuts as single-seed fruits with a hard pericarp called a shell. The seed is the edible part. Acorns, chestnuts, and hazelnuts are true nuts. But many so-called nuts are classed otherwise by botanists. For example, almonds are the seeds of drupes.

Compound fruits consist of a cluster of ripened ovaries. There are two main types of compound fruits, *aggregate fruits* and *multiple fruits.* Aggregate fruits develop from single flowers, each of which has many ovaries. Blackberries and raspberries are aggregate fruits. The strawberry is a special type of aggregate fruit. Each "seed" in a strawberry is actually a complete fruit. The flesh surrounding the seeds develops from the base of the flower rather than from the ovaries. Multiple fruits develop from a cluster of flowers on a single stem. Figs, mulberries, and pineapples are multiple fruits.

Related articles in *World Book* include:

Temperate fruits

Apple	Crab apple	Muskmelon
Apricot	Cranberry	Nectarine
Beach plum	Currant	Peach
Blackberry	Dewberry	Pear
Blueberry	Gooseberry	Plum
Boysenberry	Grape	Quince
Casaba	Loganberry	Raspberry
Cherry	Melon	Strawberry

Subtropical fruits

Avocado	Jambu	Olive
Citron	Kiwi fruit	Orange
Citrus	Kumquat	Persimmon
Custard apple	Lemon	Pomegranate
Date palm	Lime	Tangelo
Fig	Loquat	Tangerine
Grapefruit	Mandarin	Tangor
Jack fruit	Mangosteen	

Tropical fruits

Acerola	Coconut palm	Mango	Pineapple
Banana	Guava	Mangosteen	Sapodilla
Cherimoya	Litchi	Papaya	Tamarind

Other related articles

Berry	Horticulture	Raisin
Bramble	Hybrid	Rose (The rose family)
Burbank, Luther	Jam and jelly	Vegetable (Fruits)
Drupe	Nut	Vitamin
Espalier	Pectin	Wine
Food, Frozen	Prune	
Food preservation	Pruning	
Grafting		

Fruit bat. See Flying fox.

Fruit fly is any of several kinds of flies whose larvae eat their way through different fruits. Fruit flies include some of the most harmful agricultural pests.

Fruit fly

Members of one family of these insects are called *peacock flies* because of their habit of strutting on fruit. They are small insects with many colours and beautiful wings. They lay their eggs in fruit, berries, nuts, and other parts of plants. Larvae that hatch from the eggs are small white maggots that tunnel their way through the fruit. This family of fruit flies includes the destructive *Mediterranean fruit fly, Oriental fruit fly, Mexican fruit fly,* the various cherry fruit flies, and the apple maggot.

Methods of controlling these insects include the application of chemical sprays and the introduction of the flies' natural enemies. Another control technique involves the release of large numbers of sterilized male flies. A female fly that mates with one of the sterilized males cannot produce fertile eggs.

The *pomace,* or *vinegar, flies* also are called fruit flies. Their maggots feed chiefly on decaying fruit and on crushed grapes in vineyards. Scientists often use one species of pomace fly, *Drosophila melanogaster,* in heredity studies. This species is especially useful in such studies because the *chromosomes* (parts of a cell containing hereditary material) of its salivary glands are large. The species also reproduces rapidly.

Scientific classification. The peacock fly belongs to the family Tephritidae, or Trypetidae. The pomace fly forms the family Drosophilidae.

See also **Apple maggot; Compound eye** (picture: The compound eye of a fruit fly); **Mediterranean fruit fly.**

Fruit sugar. See Fructose.

Frustration tolerance. See **Child** (Aggressive and antisocial behaviour); **Baby** (From 1 to 6 months).

Fry, Charles Burgess (1872-1956), was one of Britain's best all-round sportsmen. He was a great cricketer, played soccer and rugby, and was a long-jumper. He played cricket for Surrey, Sussex, and Hampshire. He appeared in 26 Test matches, and was captain in 9 of them. His highest score was 258, for Hampshire in 1911. Fry played soccer for England. He was also a scholar, journalist, and politician. He was born in Croydon, London, and studied at Oxford University.

Fry, Christopher (1907-), is an English playwright. He has written primarily in verse, trying to re-create the beauty and eloquence of Elizabethan drama. Fry achieved his greatest popularity during the late 1940's and early 1950's. However, his attempt to revive drama in verse never became a trend.

Fry's most popular plays were the witty verse comedies *The Lady's Not for Burning* (1948), his best-known play; *A Phoenix Too Frequent* (1946); and *Venus Observed* (1950). He also made adaptations of modern French plays. *The Lark* (1955), based on a drama by Jean Anouilh, deals with the life of Joan of Arc. *Tiger at the Gates* (1955), adapted from a drama by Jean Giraudoux, is an antiwar play set during the Trojan War. Fry also wrote religious dramas such as *The Boy with a Cart* (1938) and *The Firstborn* (1948). He has also written screenplays for films, including *Ben-Hur* (1959) and *The Bible* (1966). Fry was born in Bristol.

Fry, Elizabeth Gurney (1780-1845), a British reformer, was among the first to insist that prisoners need help rather than punishment in order to become good citizens. Her work aroused the conscience of officials, and led to many reforms. She was horrified by conditions in Newgate Prison in London, particularly among the women. Many women had their children with them in prison. Although it was considered dangerous to go among the prisoners, she visited them, found work for them, started schools for their children, and insisted on better living conditions. She also began a simple form of nurses' training and a free school at her home. Elizabeth Fry was born in Norfolk, England.

Fry, Joseph (1728-1787), was a British doctor and businessman. He founded a cocoa and chocolate company, J. S. Fry and Sons, and a type-founding firm, Joseph Fry and Sons. He was born at Sutton Benger, in Wiltshire, England.

Sir Edward Fry (1827-1918) was a great-grandson of Joseph Fry. He won fame as a lawyer.

Roger Eliot Fry (1866-1934), son of Sir Edward Fry, was an artist and art critic. In 1908, he was appointed European art adviser to the Metropolitan Museum of New York City. He wrote *Vision and Design* (1920) and *Reflections on British Painting* (1934). He was born in London.

Fu-chou. See Fuzhou.

Fuchs, Sir Vivian Ernest (1908-), is a British geologist and Antarctic expert. He headed the British Commonwealth Trans-Antarctic Expedition in 1957 and 1958. Sir Edmund Hillary led the New Zealand party. The expedition, the first known party to cross Antarctica, covered 3,473 kilometres in 99 days, and made geophysical observations. Fuchs became director of the British Antarctic Survey in 1958. See also **Antarctica** (International cooperation; picture: The first Antarctic crossing).

Sir Vivian Ernest Fuchs

Fuchsia is a widely cultivated house and garden plant. There are about 100 species of fuchsias. Some grow as shrubs or trees. Others are trailing, climbing, or hanging vinelike plants. Fuchsias are native to Central and South America, Tahiti, and New Zealand.

Fuchsia blossoms resemble dangling earrings. Some fuchsias grow wild. Others are cultivated in gardens and greenhouses.

Fuchsias are commonly called *lady's eardrops*. The cultivated species usually have showy hanging flowers. The flower parts are often fleshy and in contrasting bright colours often scarlet and pink. Those fuchsias with trailing stems are popularly grown in hanging baskets.

Gardeners use cuttings of fuchsias to develop new plants. The cuttings are often stored in cool greenhouses during the winter and then planted in the spring. The fuchsia is named after the German botanist Leonhard Fuchs.

Scientific classification. Fuchsias belong to the evening primrose family, Onagraceae, genus *Fuchsia*.

Fuel is a material that provides useful energy. Fuels are used to heat and cool buildings, cook food, power engines, and produce electricity. Some fuels occur naturally and others are artificially created. Such natural fuels as coal, petroleum, and natural gas are obtained from underground deposits that were formed millions of years ago from the remains of plants and animals. These fuels, which are called *fossil fuels*, account for about 90 per cent of the energy people use today.

Synthetic fuels can be made from fossil fuels, certain types of rock and sand, and *biomass*. Biomass is the name given to such replaceable organic matter as wood, rubbish, and animal manure that can be used to produce energy. Some kinds of fuels are made from chemicals.

Most fuels release energy by burning with oxygen in the air. But some—especially chemical fuels used in rockets—need special *oxidizers* in order to burn. Oxidizers are compounds that contain oxygen. Nuclear fuels do not burn but release vast amounts of energy through the *fission* (splitting) or *fusion* (joining together) of atoms.

Since the 1970's, shortages of some fuels and concerns about the environmental effects resulting from the

burning of fuels have led people to explore other sources of energy. This article discusses five groups of fuels—(1) solid fuels, (2) liquid fuels, (3) gas fuels, (4) chemical fuels, and (5) nuclear fuels—and their uses. For information on the availability of fuels, their effect on the environment, and alternative energy sources, see **Energy supply** and **Environmental pollution.**

Solid fuels

Coal is used chiefly to produce electricity. It is burned to create heat to turn water into steam. The steam is then used to rotate *turbines* (see **Turbine**). The turbines in turn rotate *dynamos* (machines that generate electricity). Some coal is made into *coke,* a charcoallike solid that is an essential raw material in the production of iron and steel. Coal is also used to heat buildings and to provide energy for industrial machinery.

There are four forms of coal: (1) *lignite,* or *brown coal,* (2) *subbituminous coal,* (3) *bituminous coal,* and (4) *anthracite.* Bituminous coal is the most plentiful and important coal used by industry. It contains more carbon and produces more heat than either lignite or subbituminous coal. It is also the coal best suited to making coke. Anthracite is the least plentiful and hardest coal. It contains more carbon and produces more heat than other coals. But it is difficult to ignite and burns slowly.

Peat is partially decayed plant matter found in swamps called *bogs.* It is used as a fuel chiefly in areas where coal and oil are scarce. In Ireland and Scotland, for example, peat is cut, formed into blocks, and dried. The dried blocks are then burned to heat homes.

Biomass. Wood has been used as a fuel since prehistoric times—longer than any other material. Today, it is an important fuel chiefly in developing countries, where it is used for cooking and heating. In most industrial countries, it is not a major source of energy. But some paper and pulp factories, which make wood products, obtain the energy for their manufacturing processes by burning bark, sawdust, and other wood waste. Wood is also used to make charcoal.

Biomass materials other than wood are also used as fuel. For example, heat produced by burning nutshells, rice and oat hulls, and other by-products of food processing is often used to operate plant equipment.

Liquid fuels

Liquid fuels are made mainly from petroleum, but some synthetic liquid fuels are also produced. Liquid fuels are easy to store and transport. They are the major source of energy for cars, aeroplanes, and other vehicles, and they are also used to heat buildings.

Petroleum, also called *crude oil,* ranges from clear yellow-brown oils to thick, black tars. Some crude oil is burned as fuel in stoves and boilers without processing. However, most petroleum is refined to produce such fuels as *petrol, diesel oil,* and *paraffin.* Petrol is used by most motor vehicles and piston-engine aeroplanes. Diesel oil powers most trains, ships, and large trucks. Paraffin provides energy for jet aeroplanes.

Other fuel oils obtained by refining petroleum include *distillate oils* and *residual oils.* Distillate oils are light oils, which are used chiefly to heat homes and small buildings. Residual oils are heavy, thick oils. They provide energy to power utilities, factories, and large ships. They are also used to heat large buildings.

Synthetic liquid fuels include fuels made from coal, natural gas, biomass, *oil shale* (a rock that contains oil), and *bituminous sands* (sands that contain a substance from which oil can be obtained). Such fuels are processed mainly in areas where one type of fuel is abundant, but other vital fuels are scarce. For example, South Africa has several large plants that make petrol from coal. In this way, South Africa—with its abundance of coal and scarcity of petroleum—is able to provide its own motor fuel. In the Canadian province of Alberta, plentiful bituminous sands are processed to yield oil. In Brazil, such biomass as sugar cane pulp and cassava plants are used to produce fuel for cars. Some motorists in the United States use a similar fuel, called *gasohol,* in their cars. Gasohol consists of a mixture of petrol and alcohol. The alcohol in gasohol is often produced from such grains as corn and wheat.

Gas fuels

Gas fuels include natural and manufactured gases. Such fuels flow easily through pipes and are used to provide energy for homes, businesses, and industries. In many countries, vast networks of pipelines bring gas fuels to millions of consumers.

Natural gas is used to heat buildings, cook food, and provide energy for industries. It consists chiefly of methane, a colourless and odourless gas. Natural gas is usually mixed with compounds of the foul-smelling element sulphur so gas leaks can be detected.

Butane and propane, which make up a small proportion of natural gas, become liquids when placed under high pressure. When the pressure is released, they change back into gas. Such fuels, often called *liquefied petroleum gas* (*LPG*) or *liquefied natural gas* (*LNG*), are easily stored and shipped as liquids. They provide energy for use in caravans and can serve as fuel for people who live far from natural gas pipelines.

Manufactured gas, like synthetic liquid fuels, is used chiefly where certain fuels are abundant and others are scarce. Coal, petroleum, and biomass can all be converted to gas through heating and by chemical processes. Gas can also be produced by treating such biomass as animal manure with bacteria called *anaerobes.* The bacteria expel methane as they digest the waste.

Chemical fuels

Chemical fuels, which are produced in solid and liquid form, create great amounts of heat and power. They are used chiefly in rocket engines. Chemical rocket propellants consist of both a fuel and an oxidizer. A common rocket fuel is the chemical hydrazine. The oxidizer is a substance, such as nitrogen tetroxide, that contains oxygen. When the propellant is ignited, the oxidizer provides the oxygen the fuel needs to burn. Chemical fuels are also used in some racing cars.

Nuclear fuels

Nuclear fuels provide energy through the fission or fusion of their atoms. Uranium is the most commonly used nuclear fuel, though plutonium also provides nuclear energy. When the atoms of these elements undergo fission, they release tremendous amounts of heat. Nuclear fuels are used mainly to generate electricity.

They also power some submarines and ships. Nuclear energy can also be produced through the fusion of hydrogen atoms. But scientists have not yet developed the technology needed to harness such energy.

Related articles in *World Book* include:

Alcohol	Fission	Nuclear energy
Biomass	Fusion	Oil shale
Bituminous sands	Gas	Paraffin
Butane and propane	Gasohol	Peat
Carbon	Heat	Petrol
Charcoal	Heating (Sources of heat)	Petroleum
Coal		Plutonium
Coke	Hydrocarbon	Rocket (Kinds of rocket engines)
Coke oven gas	Hydrogen	
Fire	Methane	Uranium

Fuel cell is a device that produces electricity from a fuel and an *oxidizer*, a substance that combines with the fuel. The fuel and oxidizer react chemically at two separate *electrodes* (electrical conductors with terminals) to produce the direct electric current. A battery produces electricity in a similar way. But in a battery, the electrodes themselves are the fuel and oxidizer and are used up in the reaction. In a fuel cell, the fuel and oxidizer are added from outside, and the electrodes remain largely unchanged.

Today, fuel cells are used only to supply electricity for special uses. For example, fuel cells provide electricity for the U.S. space shuttle. These cells use hydrogen as the fuel and oxygen as the oxidizer. They produce about $1\frac{1}{2}$ kilowatts of power.

Scientists and engineers hope to lower the cost and increase the reliability of fuel cells. They are working to produce cells that can be run directly on low-cost fuels, such as diesel fuel, petrol, or natural gas. Oxygen in the air would be the oxidizer in these cells. Future uses for fuel cells may include furnishing electricity and heat for homes and powering military vehicles or civilian electric cars.

The main advantage of fuel cells over other methods of generating electricity is their high efficiency. Most electric power today is generated by machines that use heat. The efficiency of these machines is limited. In theory, fuel cells can change chemical energy into electricity without any change in temperature. However, today's fuel cells do produce some waste heat.

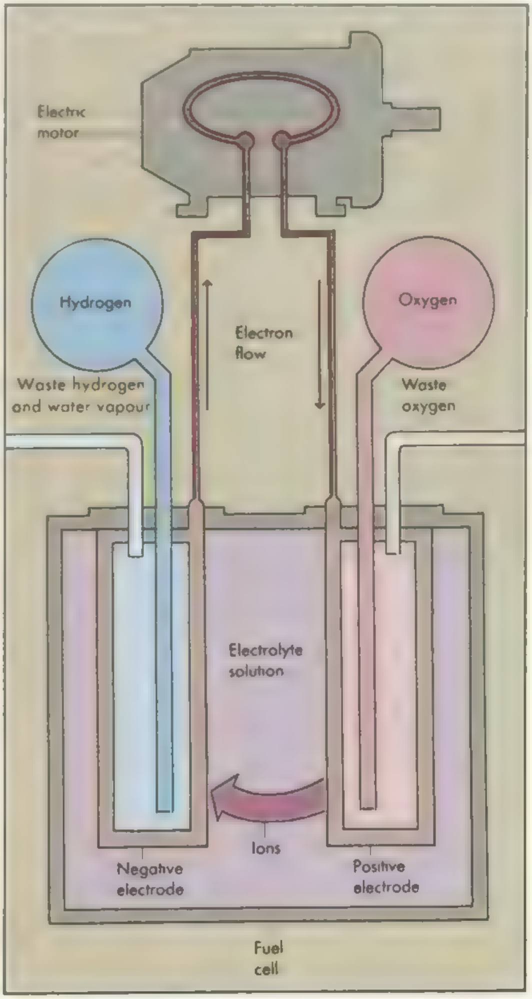
In a fuel cell, the fuel is oxidized at the fuel electrode and gives up electrons at a relatively high energy level (see **Oxidation**). These electrons are the electricity produced by the cell. The electrons flow through an outside circuit and then back to the oxidizer electrode at a lower energy level. There, a reaction with the oxidizer occurs, and *ions* (electrically charged atoms or groups of atoms) are formed. These ions flow through the *electrolyte* (current-carrying solution) between the electrodes and complete the electric circuit.

There are three types of fuel cells. *Low-temperature fuel cells* use water-based electrolytes, and *medium-temperature fuel cells* use *molten* (melted) salts. *High-temperature fuel cells,* which are the most efficient type, use solid ceramic electrolytes. This type of fuel cell can operate at 1000° C.

Fuel injection is a system for squirting fuel into the cylinders of petrol and diesel engines. It replaces the carburettor when used on petrol engines.

On most petrol engines that use fuel injection, a pump forces fuel under high pressure to a nozzle at each cylinder. The nozzles then spray the fuel into an *intake port* (chamber) near each cylinder. There the fuel partially mixes with air before a valve opens to admit the mixture into the cylinder. The fuel may be injected into the intake port in a continuous stream or periodically. Some petrol engines use a system called *single point* or *throttle body* fuel injection. This system has only one or two fuel injection nozzles. Each nozzle delivers fuel to several cylinders.

Fuel injection overcomes several disadvantages of carburettors. A carburettor mixes air and fuel. Heat from the engine vaporizes this mixture to help it burn properly. But expansion of the heated air reduces the



A fuel cell has two electrical terminals called *electrodes.* In the fuel cell above, hydrogen is pumped through the negative electrode into a solution called an *electrolyte.* The hydrogen reacts with electrically charged atoms called *ions,* forming water. This reaction causes the hydrogen to give up electrons. The electrons flow around a circuit to the positive electrode, powering the motor in the process. At the positive electrode, oxygen reacts with the water in the electrolyte and renews the ions.

amount of air going to the cylinders. Also, different cylinders can get different amounts of the fuel vapour, depending on the design of the *manifold* (pipe connecting the carburettor and cylinders) and the distance of a cylinder from the carburettor. Poor distribution of the fuel-air mixture can prevent some of the fuel from burning, resulting in lower fuel economy and higher exhaust emissions. The engine also may flood or ice up during the winter, or develop *vapour lock* during the summer (see **Vapour lock**).

Fuel injection includes both an air-flow system and a fuel system. Electronic or mechanical controls link the two systems so that the proper ratio of fuel to air is maintained in each cylinder. The nozzles help break the fuel into a fine spray so that it burns almost completely. The control of the fuel-air mixture also prevents vapour lock and enables cold engines to start quickly and run smoothly. In addition, fuel injection can improve the engine's response to changes in the position of the accelerator pedal.

All diesel engines use fuel injection. In most of these engines, the nozzles spray the fuel directly into the engine cylinders. A pump compresses the fuel to a much higher pressure than for petrol fuel injection. In some cases, a single pump is located centrally on the engine and a distributor system directs the high-pressure fuel to the cylinders. In other cases, each cylinder has a separate pump.

See also **Diesel engine** (How a diesel engine works).

Fuel shortage. See **Car** (The petrol shortage); **Transportation** (Problems of modern transportation).

Fuentes, Carlos (1928-), is Mexico's best-known fiction writer and an important figure in Spanish-American literature. Fuentes writes imaginative and complex narratives that reflect a keen intellectual awareness of history and the workings of power. He has experimented with many varieties of construction in his novels, particularly those involving shifts in place, time, and the identity of characters.

Fuentes' first novel, *Where the Air is Clear* (1958), is set in Mexico City and shifts back and forth between the city's past and present. *The Death of Artemio Cruz* (1962) also moves backward and forward in time as it presents a revolutionary's rise to power and his later moral deterioration. *Change of Skin* (1967) emphasizes the instability of personal identity. Fuentes' most ambitious novel is *Terra Nostra* (1975), which goes beyond the known facts of history to offer an alternate version of how events might have have unfolded.

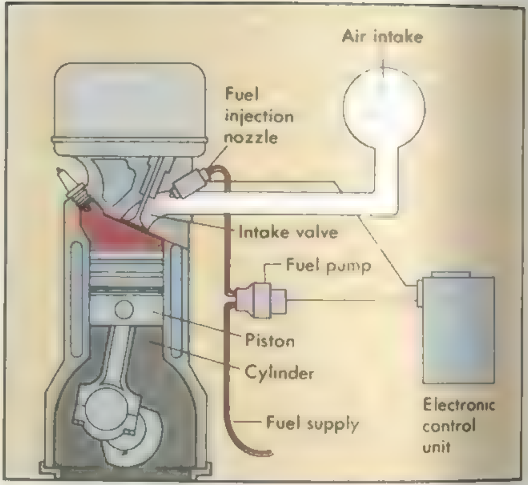
Fuentes' later work incorporates elements of popular culture. *The Hydra's Head* (1977) resembles a thriller full of political intrigue. *Distant Relations* (1982) is similar to a Gothic novel. *The Old Gringo* (1985) resembles a Western and includes special insights into relations between the United States and Mexico. Fuentes' essays were collected in *Myself with Others* (1988).

Fuentes was born in Mexico City. He was Mexico's ambassador to France from 1975 to 1977.

Fugard, Athol (1932-), is a South African playwright. Many of his plays explore the destructive effects of *apartheid,* the policy of racial segregation enforced by the government of South Africa. Fugard, who is white, has directed and acted in many of his own plays.

Fugard's first play to gain recognition was *The Blood Knot* (1961). The drama tells the story of two half-brothers, one with light skin and the other with dark skin. *Boesman and Lena* (1969) concerns two impoverished people of mixed race and their struggle for survival. Fugard joined black South African actors John Kani and Winston Ntshona in writing the comedy *Sizwe Banzi Is Dead* (1972), in which a black man trades identity papers with a corpse. *"Master Harold" . . . and the Boys* (1982) deals with the relationship between a white boy and a black waiter, showing how their friendship is disrupted by racism.

Harold Athol Lannigan Fugard was born in Middleburg, Cape Province. He has spent most of his life in Port Elizabeth. There, in 1963, he founded the Serpent Players, South Africa's first successful nonwhite theatre group.



A fuel injection system pumps petrol to a nozzle, which sprays the fuel into a chamber. There, the fuel is mixed with air before a valve opens to admit the mixture into the cylinder.

Fugitive slave laws were laws that provided for the return of runaway slaves who escaped from one American state to another. A clause in the Northwest Ordinance of 1787 provided for the return of slaves who had escaped to the free Northwest Territory. In 1793, Congress passed a fugitive slave law which allowed owners to recover their slaves merely by presenting proof of ownership before a magistrate. An order was then issued for the arrest and return of the escaped slaves, who were allowed neither a jury trial nor the right to give evidence on their own behalf. Under this law, free blacks living in the North were sometimes kidnapped and taken South as slaves. For this reason, some Northern states gave orders not to help recover fugitive slaves.

The Compromise of 1850 included a provision that imposed heavy penalties on people who aided a slave's escape or interfered with a slave's recovery. Some Northern states passed *personal liberty laws,* which sometimes prohibited state and local officers from obeying national fugitive slave laws.

Fugue is a musical composition in which several voices or instruments repeat a number of melodies with slight variations. A fugue is based on *counterpoint,* a

composing technique in which two or more melodies are combined (see **Counterpoint**).

A fugue begins with a section called the *exposition,* in which the melodies are first stated. The basic melody is called the *subject.* It is followed by a melody called the *answer.* The answer resembles the subject but it is performed in a different but related key. A third melody, called the *countersubject,* accompanies the answer. The other melodies then enter in sequence. After all the performers state the subject, the exposition is complete. The term *fugue* comes from the Latin word *fuga,* meaning *flight.* The subject seems to be "fleeing" from the other melodies that chase it.

After the exposition, the subject is repeated in different but related keys. In most fugues, brief passages called *episodes* link the entrances of the subject. Fugues generally end in *stretto,* with the subject and answer performed closer together than in the exposition.

The fugue as a type of independent composition began in the 1600's. The German composer Johann Sebastian Bach became noted for his fugues.

Fuji, Mount. See **Mount Fuji.**

Fujiyama. See **Mount Fuji.**

Fukuoka (pop. 1,157,111) is an important commercial centre of the island of Kyushu, in Japan. The city stands on Hakata Bay, in the northwestern part of the island (see **Japan** (political map)).

Its factories produce such products as dolls, electrical goods, paper, pottery, rubber, and textiles. Fukuoka's exports include bamboo, machinery, and plate glass. Coalfields lie nearby. The Imperial University of Kyushu, founded in 1910, is at Fukuoka.

Fulani are a people of the grassy regions of western Africa. The more than 5 million Fulani live as far west as Senegal and as far east as Cameroon. For hundreds of years, most Fulani have been cattle herders and have lived as minority groups among various agricultural peoples. The Fulani are known as *Fula, Foulah,* or *Peul* in some African nations.

The Fulani originated in what are now Senegal and Guinea. A group of Fulani called the Tukulor (also spelled *Toucouleur*) built a powerful empire there during the A.D. 600's. Descendants of these Fulani often intermarried with those they conquered. The Fulani gradually spread eastward and reached Nigeria and Cameroon in the early 1800's.

Fulani girls often wear earrings and necklaces. The Fulani are one of the largest ethnic groups in Nigeria.

Many Fulani became Muslims in the early 1700's and conquered a number of their neighbours in holy wars. Between 1804 and 1809, Uthman Dan Fodio, a Muslim religious leader, conquered most of the Hausa states of Northern Nigeria. He then established an empire consisting of several Fulani states. Uthman's empire remained powerful until the British conquered Northern Nigeria in 1903. Many Fulani still live in the northern part of Nigeria.

Fulbright, J. William (1905-1995), a United States Senator, served as a Democrat in the U.S. Senate from 1945 to 1974. He was chairman of the Senate Foreign Relations Committee from 1959 to 1974. Fulbright became a leading critic of U.S. involvement in the Vietnam War (1957-1975). During the 1960's and early 1970's, Fulbright was a spokesman for those who wanted Congress to have more control over presidential war-making powers. He sponsored the Fulbright Act of 1946, which provides funds for exchanges between U.S. and foreign students (see **Fulbright Scholarship**).

James William Fulbright was born in Sumner, Missouri, U.S.A. and entered the University of Arkansas, U.S.A. at the age of 16. He graduated from Arkansas in 1925 and from the George Washington University Law School in Washington, D.C. in 1934. From 1925 to 1928, he studied at Oxford University in England as a Rhodes scholar. Fulbright served as president of the University of Arkansas from 1939 to 1941 and was elected to the United States House of Representatives in 1942. He criticized U.S. foreign policy in his books, which included *Old Myths and New Realities* (1964) and *The Arrogance of Power* (1967).

Fulbright Scholarship is an award made by the United States government for research, teaching, or graduate study. The scholarship programme was begun under the Fulbright Act of 1946, named after its sponsor, Senator J. William Fulbright of Arkansas. It seeks to promote better understanding between the peoples of the United States and other countries.

The annual awards allow U.S. citizens to study or work in other countries and permit people of other countries to study or work in the United States. About 110 countries participate in the programme annually, and more than 155,000 scholarships have been awarded, about 55,000 of them to U.S. citizens.

Money for the awards came at first from the sale of surplus World War II equipment to other countries. The U.S. government and participating countries and universities now fund the programme. The U.S. Information Agency (USIA) administers it. The Board of Foreign Scholarships selects the award winners.

Fulcrum. See **Lever.**

Fulham. See **Hammersmith and Fulham.**

Full stop. See **Punctuation.**

Fuller, Buckminster (1895-1983), was an American designer who sought to express the technology and needs of modern life in buildings and enclosures of space. He had an intense interest in expanding people's ability to control large areas of their environment and still have a close relationship with nature. His designs show the influence of such natural molecular structures as the tetrahedron.

Buckminster Fuller became famous for designing large, lightweight prefabricated enclosures called *geodesic domes.*

Fuller solved many design problems in such diversified fields as cars, buildings, and cities. His influence spread through his lectures, teaching, and writings. A collection of essays he wrote discussing his theories and designs was published as *Ideas and Integrities* (1963).

Richard Buckminster Fuller was born in Milton, Massachusetts, U.S.A. He gained international attention in 1927 by designing an all-metal prefabricated home called a *Dymaxion house.* Between 1932 and 1935, he designed a revolutionary bullet-shaped three-wheeled car. After World War II (1939-1945), he concentrated on designing large, lightweight prefabricated enclosures that he called *geodesic domes.*

Fuller, Roy (1912-1991), was an English poet and author. His first published poetry was *Poems* (1939). It was followed by a collection entitled *The Middle of a War* (1942). *A Lost Season* (1944) is a collection of poems on African themes. His *Collected Poems* was published in 1962. He wrote two books for children, *Savage Gold* (1946) and *With My Little Eye* (1948). His novels include *Image of a Society* (1956). Roy Broadbent Fuller was born at Failsworth, Lancashire, and educated in Blackpool, Lancashire.

Fuller's earth is a claylike material that bleaches and purifies fats and oils. It consists of 50 to 80 per cent silica. Bleaching and purifying occur when particles of fuller's earth remove asphalt and resin from fatty or oily substances. The particles do this by *adsorbing* (collecting and holding) the asphalt and resin (see **Absorption and adsorption**).

Petroleum companies use fuller's earth to purify crude oil and to lighten its colour. Fuller's earth is also used to purify animal and vegetable oils. People once used a powdered form of it to remove grease from cloth and wool. Fuller's earth gets its name from this process, called *fulling.*

Fulmar, an ocean bird, is one of the petrels. The northern fulmar is the size of a duck. Its yellow bill is nearly as long as its head. The feet of the fulmar are webbed. The hind toe is reduced to a claw.

This bird breeds on rocky shores and makes a shallow nest in high, rocky places. It lays one egg in the nest. The fulmar feeds on any animal matter, but prefers fatty substances like whale blubber. The fulmar is valuable for its feathers, down, and oil.

The northern fulmar lives in far northern seas from Melville Island to Greenland and Svalbard. It is common around Saint Kilda Island, the Outer Hebrides, and other parts of Scotland. In winter, it goes south as far as the southern coast of Britain, Europe, and the Massachusetts coast of North America.

The southern fulmar is distinctive as the only pale-coloured sea bird of the region. It breeds on the Antarctic continent and islands of the Antarctic Ocean, such as South Georgia. During the southern winter this fulmar migrates north, beyond 45° S. It can often reach as far north as 10° S as it follows the Humboldt current along the western coast of South America. The southern fulmar is an occasional visitor to the coast of Australia and South Africa.

Scientific classification. The fulmar belongs to the family Procellariidae. The northern fulmar is *Fulmarus glacialis,* the southern fulmar is *F. glacialoides.*

See also **Petrel.**

Fulton, Robert (1765-1815), an American inventor, civil engineer, and artist, is best known for designing and building the first commercially successful steamboat. Fulton also contributed to the development of the submarine.

Early years. Fulton was born Nov. 14, 1765, on a farm in Lancaster County, Pennsylvania, U.S.A. He went to Philadelphia, Pennsylvania, at the age of 17, and was apprenticed to a jeweller. He soon began to win fame as a painter of miniatures and portraits on ivory for rings, brooches, and other items sold by jewellers. He saved enough money to buy a farm for his mother.

At the age of 21, Fulton went to England to study with an American artist, Benjamin West. In London, Fulton was able to make a modest living as an artist. But he became increasingly interested in scientific and engineering developments, and after 1793 he painted only for amusement. Fulton travelled and studied science and mathematics. He also learned French, Italian, and German.

The inventor. Fulton's first enthusiasm was for canal development. He designed new types of canal boats, a system of inclined planes to replace canal locks, and a dredging machine for cutting canal channels.

About 1797, Fulton turned his attention to the submarine. He foresaw that submarines might influence sea war greatly and thought they might reduce piracy. Fulton's experimental submarines were able to dive and surface, but he never solved the problem of propulsion under water.

In 1802, Robert R. Livingston, the United States minister to France, interested Fulton in developing a steamboat. Livingston became Fulton's business partner. An experimental boat, launched on the Seine River in Paris in 1803, sank. But a second boat, which was built in the same year, operated successfully.

The ***Clermont.*** Fulton directed the building of a steamboat in New York in 1807. He called it *The North River Steamboat,* but it became known as the *Clermont.* On Aug. 17, 1807, the vessel began its first successful trip up the Hudson River from New York City to Albany, New York. After some alterations, it sailed in regular passenger service on the Hudson.

The *Clermont* was not the first steamboat to be built, but it was the first to become a practical and financial success. Part of Fulton's success was due to his concern for passenger comfort. After the financial and mechanical success of his first boat, Fulton built and operated others and expanded his activities to other parts of the country.

Fulton designed and built a steam warship, *Fulton the First,* for the defence of New York harbour in the War of 1812, but the ship never fought in battle.

See also **Clermont** and **Ship.**

Fumarole is a hole or vent in the ground that gives off volcanic gases. Most fumaroles occur in volcanic regions, such as Yellowstone National Park in the United States. The gases given off usually are steam mixed with carbon dioxide, hydrogen, hydrogen sulphide, hydrogen chloride, and nitrogen. Some of the gases are poisonous. Others cause choking. Fumaroles that give off sulphurous gases are called *solfataras.*

See also **Hot springs.**

Fumigation is a method of killing pests that involves the use of toxic gases. It is widely used to eliminate weeds, *nematodes* (roundworms), and other pests from cropland. It is also used to protect such foods as grains, nuts, and spices from rats and insects during storage. Goods shipped between countries often are fumigated to prevent pests and diseases from spreading from one country to another. Houses, apartments, and other buildings are sometimes fumigated to kill cockroaches, termites, and other insects.

The chemicals used in fumigation are called *fumigants.* They work well only in an enclosed area. For example, stored foods commonly are covered with plastic sheets during fumigation. The sheets trap the gases beneath them, enabling the foods to absorb the fumigants. Some farmland is treated to kill nematodes by injecting fumigants into the soil, which acts as a cover. Plastic sheets are generally used as an additional cover for fields fumigated against weeds, insects, and plant diseases. The sheets are removed about 24 to 48 hours after the fumigants have been applied. The fields can be safely planted about one to two weeks later. By then, the gases have been *dissipated* (released) from the soil.

Fumigants are poisonous to people and must be handled with care. They are usually applied by trained, licensed professionals. Commonly used fumigants include cyanide, formaldehyde, and methyl bromide. Foods that have been fumigated are safe to eat only after the fumigant has been dissipated.

See also **Insecticide; Pesticide.**

Funafuti (pop. 2,800) is the capital of Tuvalu, a small island country in the South Pacific Ocean. Funafuti is one of the world's smallest and most unusual national capitals. It is the largest islet of an *atoll* that is also called Funafuti. An atoll is a ring-shaped coral reef that surrounds a lagoon. The Funafuti atoll consists of 30 islets that have a total area of about 280 hectares.

All the people live in Fongafale village on the islet of Funafuti. The main government offices of Tuvalu, and a hospital, a hotel, and a jail, are on the islet. A wharf and an airport are located nearby. Funafuti was the site of a United States military base during World War II.

See also **Tuvalu**

Funchal (pop. 48,638), is the capital, largest city, and chief port of the Madeira Islands. The Madeiras belong to Portugal and lie in the Atlantic Ocean off the northwest coast of Africa. Funchal is on the southern coast of the island of Madeira. The city's pleasant climate makes it a popular resort.

Portuguese settlers founded Funchal in 1421. The city has many beautiful gardens and a cathedral that dates from the 1400's. Funchal's economy is based on the tourist trade and the export of sugar and the famous Madeira wines. The city also produces ceramics and linen embroidery. It has a modern airport, and airlines connect the city with western Europe.

See also **Madeira Islands** (picture: The harbour of Funchal).

Function, in mathematics. See **Algebra** (Functions); **Calculus** (Functions).

Functional illiteracy. See **Illiteracy.**

Fundamentalism is a broad movement within Protestantism in the United States. The fundamentalist movement tries to preserve what it considers the basic ideas of Christianity against criticism by liberal theologians.

At the end of the 1800's, many liberal religious scholars challenged the accuracy of the Bible. They also used historical research to question previously accepted Christian beliefs. The liberals attempted to adjust Christian theology to new discoveries in the sciences, particularly in biology and geology. Many Christians believed the work of the liberals threatened the authenticity and even the survival of Christianity.

From 1910 to 1915, anonymous authors published 12 small volumes entitled *The Fundamentals.* Fundamentalism got its name from these booklets. The authors tried to explain what they felt were basic Christian doctrines that should be accepted without question. These doctrines included the *infallibility* (absolute accuracy) of the Bible, including the story of creation and accounts of miracles. Other doctrines included the Virgin Birth of Jesus, Christ's atonement for the sins of humanity through His Crucifixion, and His Second Coming.

Fundamentalism began in the North of the U.S.A., but it has gained its greatest strength in Southern areas. Baptists and Presbyterians have been most directly affected by the theological debates between liberal and conservative Protestants. Fundamentalism, however, has had an influence on all Protestant denominations, particularly such groups as the Church of God, Assemblies of God, and Pentecostal churches. Television evangelism has also been influenced by conservative fundamentalist beliefs. Organizations within a movement called the New Religious Right have adopted social and political positions based on a literal use of Biblical texts. The infallibility of the Bible remains an important fundamentalist issue today.

The term *fundamentalism* is also used to describe conservative trends in other religious denominations, notably Judaism and Islam.

See also **Scopes trial.**

Funeral customs are special ceremonies performed after a person dies. Throughout history, humankind has developed such customs to express grief, comfort the living, and honour the dead. The word *funeral* comes from the Latin word *funus,* which means funeral procession, death, or dead body.

Nearly all religions include the belief that human beings survive death in some form. For many people, a funeral symbolizes a passage from one life to another, rather than the end of a person's existence. Such a ceremony, which is associated with the completion of one phase of life and the beginning of another, is called a *rite of passage.* Other rites of passage include baptism, initiation into adulthood, and marriage.

Funeral customs vary from society to society, but many of the same practices are found throughout the world. These practices include public announcement of the death; preparation of the body; religious ceremonies or other services; a procession; a burial or other form of disposal; and mourning.

Preparation of the body varies among peoples. Typically, however, the corpse is laid out and washed. Sometimes it is painted or anointed with oils. It is then dressed in new or special garments or wrapped in a cloth called a *shroud.* In most societies, the body is put in a coffin, also called a casket, or other container.

Many peoples hold an all-night watch called a *wake* beside the corpse. They may do so in the belief that the wake comforts the spirit of the dead or protects the body from evil spirits. In the past, another reason for a wake was to watch for signs of life. Before modern tests were developed, an unconscious person might be mistaken for dead.

In some countries, funeral directors can preserve bodies by a process called *embalming.* An embalmer removes the blood and injects a chemical solution into the veins to retard decay. In most western countries, refrigeration is used as an alternative method of preservation.

Funeral customs include the practice of cremation. The body is sometimes burned on a funeral pyre, such as this one in Bali, Indonesia.

The funeral is usually a religious service, held in a church or other place of worship. It includes prayers, hymns, and other music. Speeches called *eulogies* may be made to recall and praise the dead person. The body of the dead person is taken to the funeral in a vehicle called a *hearse.* Friends and relatives, known as *mourners,* follow the hearse in procession and give bouquets or wreaths of flowers, which decorate the coffin. In Australia, New Zealand, and the United Kingdom the body of the dead person is usually enclosed in the coffin during the whole ceremony. But in some countries, such as the Soviet Union, the coffin is open and the dead person can be seen. If the body is buried, a final brief ceremony is held at the grave side. If the body is cremated, the ashes are usually scattered at a later date, or placed in a memorial wall or garden. After many funerals, the mourners return with the bereaved family to their house and share food. Later, a tombstone or other monument is erected to record the dead person's life and mark the place of burial.

Burial is the most common method of disposal in Christian, Jewish, and Muslim countries. Human burial developed from the belief that the dead rise again. Like a seed, according to this belief, a body is planted in the earth to await rebirth.

Cremation is customary in Buddhist and Hindu nations and is increasing in most western countries. However, Orthodox Jews, some Roman Catholics, and some Protestant groups oppose this practice. They believe the body is the temple of the soul or of the Holy Spirit and should not be destroyed. Other religions do not object to cremation.

Some societies dispose of their dead in other ways. For example, the Sioux Indians of North America place their dead on high platforms. Some groups of Aborigines, the original inhabitants of Australia, leave dead bodies in trees. In Tibet, bodies are sunk in water. The Parsis, a religious group who live mainly in India, take their dead to special enclosures called *towers of silence.* There, birds pick the bones clean. The Parsis believe the earth and fire are sacred and must not be violated by burying or burning a corpse.

Mourning is the expression of grief after a death. People in mourning may deny themselves amusement, avoid certain foods, or wear special clothing. Until the 1940's, Australians, Americans and Europeans wore black armbands and hung funeral wreaths on their doors while in mourning. Some societies regard a period of mourning as a time of uncleanliness. They believe death contaminates the survivors and makes them *taboo* (set apart as cursed or sacred). See **Taboo.**

History. As early as 60,000 years ago, prehistoric people observed special ceremonies when burying their dead. Neanderthal graves, for example, contain tools, weapons, and evidence of flowers. The ancient Egyptians and other early peoples placed food, jewels, and other goods in tombs. Such provisions showed the belief that a person continued to exist after death and had the same needs as in life. The Egyptians also developed embalming into an advanced technique called *mummification.* They believed the spirit would someday return to inhabit the body. Therefore, it had to be preserved to prevent the soul from perishing.

The Greeks believed that the souls of the dead had to

be ferried across the mythical river Styx. They placed a coin in the mouth of the corpse so it would have the fee to pay Charon, the ferryman.

During the 1900's, traditional funeral and mourning practices have declined in Australia, Europe, and the United States. Ideas about death and the treatment of the dead are changing. Criticism of many funeral practices as needlessly elaborate and expensive has led many people to seek alternatives. For example, some families prefer to hold a memorial service or a non-religious funeral at their home or at a local community hall.

However, the funeral fulfils important emotional needs. It focuses attention on the grief of the survivors and provides a public ceremony that helps them acknowledge and accept their loss. A funeral also helps survivors express feelings and discharge grief.

Related articles in *World Book* include:

Catacombs	Mummy
Cremation	Necropolis
Crypt	Potter's field
Death	Pyramids
Embalming	Sarcophagus
Epitaph	Tomb
Funeral director	Wake
Mask (Burial masks and death masks; picture)	

Fungal disease. Many kinds of fungi live and feed on the tissues of living plants and animals (see **Fungi**). These *parasites* often cause diseases in the plants and animals they infect.

Diseases of plants. The most important fungi that live on plants include smuts, rusts, and mildews. They affect many kinds of plants. One kind of fungal disease, Dutch elm disease, caused by a fungus, has destroyed populations of elms throughout Europe and North America. Fungal diseases in plants sometimes spread rapidly.

To avoid crop losses, farmers may use *fungicides,* chemicals that kill fungi (see **Fungicide**). Breeders try to develop plants that will resist fungus attacks.

Diseases of human beings and animals. Fungi that infect people and animals may cause skin disorders or serious illness. *Actinomycosis,* or lumpy jaw, is a fungal disease of cattle and other animals. But rarely it may also affect people. Other fungal diseases of human beings include *blastomycosis, coccidioidomycosis,* and *candidiasis.* These diseases often attack the lungs. *Thrush,* a fungal disease of the throat, is found mainly in infants. *Tinea* (ringworm) affects parts of the skin.

Various bacteria that live on the skin and mucous membranes help prevent fungal infections. The use of certain antibiotics to treat bacterial infections sometimes results in the destruction of the body's helpful bacteria as well. In such cases, a fungal infection may set in. However, doctors can effectively treat many fungal infections with antibiotics.

Related articles in *World Book* include:

Athlete's foot	Mildew
Blight	Ringworm
Damping-off	Rot
Dutch elm disease	Rust
Ergot	Smut
Fungi	Thrush (disease)
Fungicide	Wilt
Histoplasmosis	

Fungi are organisms that lack chlorophyll, the green colouring matter that many plants use to make food. Fungi cannot make their own food. Instead, they absorb food from their surroundings.

According to *mycologists* (scientists who study fungi), there are over 100,000 species of fungi. Yeasts and other one-celled fungi are too small to be seen without a microscope. But most types can be seen with the unaided eye. Some of the most common fungi include mildews, moulds, mushrooms, and plant rusts.

Parts of a fungus. Except for yeasts and other one-celled fungi, the main part of a fungus consists of thousands of threadlike cells called *hyphae.* These tiny, branching cells form a tangled mass called a *mycelium.* In many kinds of fungi, the mycelium grows beneath the surface of the material on which the organism is feeding. For example, the mycelium of a mushroom often grows just beneath the surface of the soil. The umbrella-shaped growth known as a mushroom is actually the *fruiting body* of the fungus. The fruiting body produces cells called *spores,* which develop into new hyphae. Spores are smaller and simpler than the seeds of plants, but both enable an organism to reproduce.

Some bread moulds and microscopic species of fungi bear spores in tiny structures called *sporangia.* In black bread mould, the sporangia form at the tips of upright hyphae called *sporangiophores.* Other hyphae called *stolons* spread over the surface of the bread. They are anchored by *rhizoids* (rootlike structures). Groups of sporangia usually form above the rhizoids.

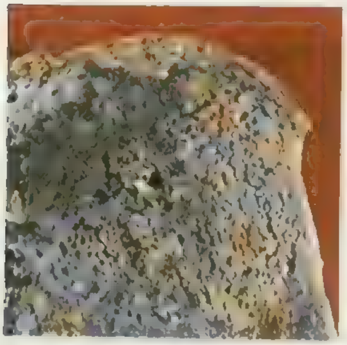
How a fungus lives. Fungi live almost everywhere on land and in water. Some fungi are parasites that feed on living plants and animals. Other fungi, called *saprophytes,* live on decaying matter. Still other fungi live together with other organisms in ways that are mutually beneficial. Such a relationship is called *symbiotic.* For example, a fungus and an organism called an *alga* may live together symbiotically to form a *lichen* (see **Lichen**). Some fungi also live with the roots of plants in a symbiotic relationship known as a *mycorrhiza.* The fungus takes carbohydrates from the plant. In return, the fungus helps supply the plant with water and such important minerals as phosphorus, potassium, iron, copper, and zinc.

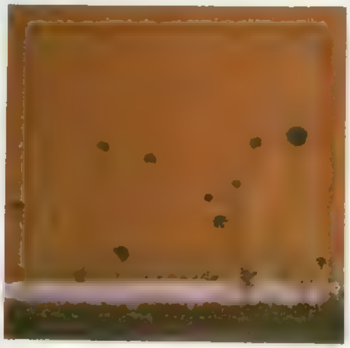
Most species of trees, shrubs, and herbs have mycorrhizal relationships with fungi. Certain gill fungi have a mycorrhizal relationship only with particular species of trees. For example, the fly agaric fungus, which has a red cap spotted with white, forms such an association only with the roots of birch trees. Orchids are a group of plants that commonly have a mycorrhizal association to help them absorb water and mineral salts.

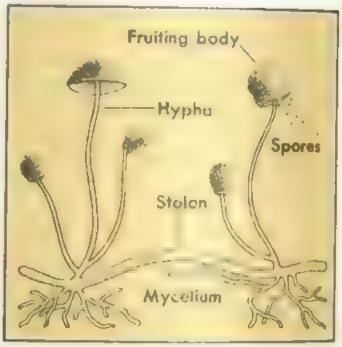
Fungi cannot produce their own food because they do not contain chlorophyll. They take carbohydrates, proteins, and other nutrients from the animals, plants, or decaying matter on which they live. Fungi discharge chemicals called *enzymes* into the material on which they feed. The enzymes break down complex carbohydrates and proteins into simple compounds that the hyphae can absorb.

Most kinds of fungi reproduce by forming spores. Some spores are produced by the union of *gametes* (sex cells). Others, called *asexual* or *imperfect* spores, are produced without the union of gametes. Many fungi

Black bread mould Black bread mould is one of the most common fungi. A 10-day growth of this mould covers the slice of bread shown on the left. The tiny fruiting bodies of the mould can be seen in the photograph in the centre. The diagram on the right shows the structure of the mould in more detail.





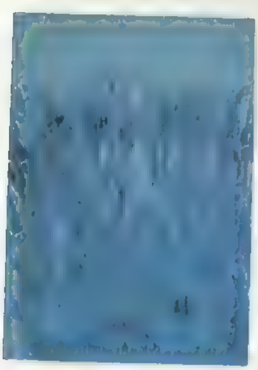


produce spores both sexually and asexually. Many spores are scattered by the wind, and others are transported by water or by animals. Mushrooms and some other fungi forcefully discharge their spores. A spore that lands in a favourable location *germinates* (starts to grow) and eventually produces a new mycelium.

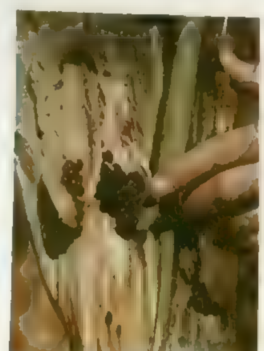
Yeasts can reproduce by forming spores, but many kinds of yeasts reproduce rapidly by *budding*. When a yeast buds, a bulge forms on the cell. A cell wall grows and separates the bud from the original yeast cell. The bud then develops into a new cell.

Common kinds of fungi. *Gill fungi,* such as toadstools and mushrooms, produce their *spores* (one-celled organisms) in gills on the underside of their heads (see **Mushroom**). Many mushrooms, such as *parasol mushrooms* and *field mushrooms,* live on plant and animal remains in the soil.

Fairy-ring fungus, a gill fungus, is the cause of the discoloured circles of dying vegetation commonly seen on lawns and pastures. The *fairy rings* were once said to be caused by dancing fairies. Several kinds of fungi grow in rings, but the rings caused by this particular fungus are characteristic. The fungus grows outwards from the centre in a circle. At the leading edge of growth, the fungus releases ammonium compounds, which are converted to nitrates by bacteria in the soil.



Some penicillium moulds, such as the one shown above, cause citrus fruit to spoil. Others ripen certain cheeses.



Smut has infected this maize plant. Smuts and other parasitic fungi cause great damage to grain crops.

Pore fungi have their spores in tiny pores on the underside of their *fructifications* (reproductive bodies). Many of them, such as *bracket fungi,* attach themselves to living, dying, or dead trees. Some of them are hard, like wood, and live for many years. Dry rot, species *Merulius lacrymans,* destroys timber, particularly in old houses. Dry rot can spread rapidly from its original site of infection by sending out thick, vein-like branches that penetrate mortar and even bricks, until they reach more wood. Despite its name, dry rot needs dampness as well as stagnant air to grow.

Some types of gill fungi and pore fungi are collected and eaten as food. However, many fungi are poisonous and should not be eaten. Edible wild mushrooms are especially popular in Europe, the Soviet Union, and Japan. They are mainly used to flavour other foods. Some edible mushrooms are dried or pickled during the winter months, so they can be eaten at a later date. *Truffles* are fungi that grow underground. They are sought using dogs or pigs, mainly in France and Italy, and are very expensive to buy (see **Truffle**).

Moulds include bread moulds that reproduce rapidly by means of asexual spores borne in black-walled, stalked capsules called *sporangia.* These moulds grow well on damp bread, where their numerous sporangia look rather like black-headed pins embedded in a fluffy white pincushion. Some people call them *pinmoulds* on account of their appearance. Blue moulds and green moulds, belong to the genus *Penicillium.*

Some moulds produce important drugs called *antibiotics.* Antibiotics weaken or destroy bacteria and other organisms that cause disease. Penicillin, the first and most important antibiotic, was discovered in 1928 by Sir Alexander Fleming, a British bacteriologist. *Penicillium notatum* is one of several green moulds that produce penicillin.

Some fungi cause great damage. Parasitic fungi destroy many crops and other plants. Important parasitic fungi that attack plants include mildews, rusts, and smuts. Others produce diseases in animals and people. Some mushrooms are poisonous and can cause serious illness or death if eaten. Moulds spoil many kinds of food. In damp climates, mildews and other fungi can ruin clothing, bookbindings, and other materials. Fungi may also cause wood to decay or rot.

Scientific classification. Botanists traditionally classified fungi in the plant kingdom. Today, however, most biologists consider fungi to be a separate kingdom called Fungi.

Related articles in *World Book.* See **Fungal disease** and its list of *Related articles.* See also the following articles:

Mould	Parasite	Saprophyte
Mushroom	Puffball	Yeast

Fungicide is a chemical substance used to kill growths called *fungi* that are harmful to human beings and plants. Diseases caused by fungi can destroy or seriously damage food crops. A fungal disease destroyed the potato crop in Ireland, resulting in the Irish potato famine, which caused the starvation of about 750,000 people in the 1840's. Fungus also caused the chestnut blight that killed thousands of American chestnut trees in the United States during the early 1900's.

Great quantities of fungicides are sold each year to protect plants and human beings from fungal diseases. Fungicides are sprayed or dusted onto plants to kill fungal diseases called *rusts, mildews, smuts,* and *moulds.* They are used to protect potatoes, apples, and other crops from fungal diseases called *blight* and *scab.* Many kinds of seeds are dipped in a fungicide to prevent *damping-off,* a disease that kills young plants.

Human beings use preparations containing a fungicide to prevent such diseases as *athlete's foot.* Fabrics are treated with fungicides to prevent rotting.

Inorganic fungicides are made from metal compounds. Copper compounds have been widely used to protect against mildew on fruit trees, grapevines, and vegetables, and to treat seeds. Among the copper compounds is Bordeaux mixture, which contains copper sulphate and lime. Other compounds contain carbonate, chloride, hydroxide, and sulphate. Sulphur and lime-sulphur are used to control scab and another fungal disease called *brown rot,* which attack fruit.

Organic fungicides are chemical compounds that contain carbon, hydrogen, and oxygen atoms. Most organic fungicides are *synthetic* (artificially created). Formaldehyde and chloranil are used to treat seeds and potatoes. Maneb, nabam, and zineb are sprayed onto the leaves of fruit trees and onto vegetables and cereal grasses to kill rusts and fungi that cause blight. Other organic fungicides are used to prevent rot in wood, rope, tents, and some paints.

Fungicides must be poisonous to fungi. But they must not be harmful to the plants or animals they are supposed to protect. Fungicides should be used with care, because many will be harmful to plants if they are applied too heavily. Many fungicides are poisonous to humans. They should be stored where small children, livestock, and pets cannot get them. Some fungicides also leave poisonous deposits on food crops. The deposits must be cleaned off before these crops are used.

Related articles in *World Book* include:

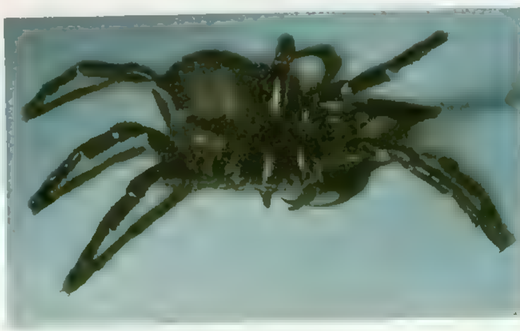
Fungal disease	Mildew	Pesticide (Types)
Fungi	Mould	Rust
Insecticide		

Funj Sultanate was a Muslim empire in what is now Sudan, in northeastern Africa. The empire began in the early 1500's and fell in 1821. It reached its height between 1600 and 1650 when Funj armies conquered neighbouring peoples. The Funj became greatly feared in the region between the Red Sea and the Nile River.

The origin of the black-skinned Funj people is uncertain. They may have descended from Shilluk raiders from the White Nile region. In the early 1500's, the Funj adopted Islam, the Muslim religion. In 1504, they founded their capital, Sennar, south of the present-day city of Wad Madani. The sultanate went on to conquer the northern region of Sudan and nearly all the area between the Blue Nile and White Nile, south of the present-day city of Khartoum. From 1600 to 1650, the Funj used a slave army created by the sultan Badi II Abu Daqn to further extend their empire.

Between 1650 and 1750, the Funj nobles became jealous of the sultans' power and revolted frequently. Finally, in 1761, a group of officers deposed the ruling sultan. A period of decline followed, and the empire fell in 1821 after Egypt invaded it.

Funnel web spider is a type of venomous Australian spider whose bite can cause death to human beings. These dark-brown to black spiders, when full-grown, vary from about two to about five centimetres in length. The many kinds of funnel web spiders are found in southeastern Australia—from southern Queensland around to the Eyre Peninsula in South Australia—and in Tasmania. Most funnel web spiders live singly in ground burrows, which they build in sheltered locations under logs, rocks, or heavy ground litter. They spin funnel-shaped entrances for these burrows. A few kinds of funnel web spiders are tree dwellers. The spiders feed mainly at night on insects and other small creatures.



A funnel web spider

Contrary to popular opinion, funnel web spiders cannot jump, though the male spiders are excitable and readily rear up into the strike position. Of the many people bitten by these spiders, about a dozen have died. The discovery of an antivenene to the spider's bite was announced in 1980.

Scientific classification. Funnel web spiders belong to the family Dipluridae, genus *Atrax.* The two best-known species are *A. robustus,* the Sydney funnel web; and *A. formidabilis,* the northern tree funnel web.

See also **Spider.**

Funny bone is not a bone, but a sensitive place at the bend of the elbow. In this area, the *ulnar nerve* lies between the skin and bone. The nerve is relatively unprotected because it lies near the surface. Even a slight blow on this area stimulates the nerve. This stimulation produces pain and a tingling sensation that travels into the ring finger and little finger.

Fur is the thick growth of hair that covers the skin of many kinds of animals. People make coats and other warm clothing from fur. They value fur for its beauty as well as for the warmth that it provides.

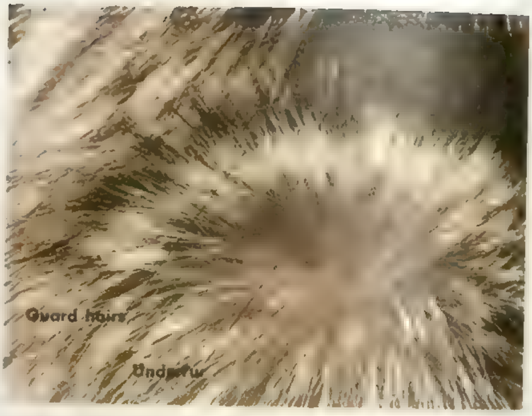
Fur consists of a combination of stiff, oily *guard hair* on top and thick *underfur* beneath. The guard hair sheds moisture, and the underfur acts as an insulating blanket that keeps the animal warm.

Because fur comes from wild animals, it cannot be flawless like cloth, which is manufactured from fibres. The work involved in repairing imperfect pelts and then sewing them together into clothing contributes to the high cost of fur garments. In some years, the scarcity of fur-bearing animals makes prices rise even higher.

Fur that comes from animals is called *natural fur.* Manufacturers also produce *artificial fur,* which looks like natural fur but costs less and is not as warm.

Prehistoric people wore animal skins for warmth and protection. They also used fur skins for blankets, rugs, and wallhangings. During the 400's B.C., an active fur market operated in Athens, Greece. Fur became a luxury during medieval times, when only kings and princes wore such expensive furs as ermine and sable. The desire for furs stimulated much of the early exploration of North America. In the 1600's, fur trading became the most important industry in Canada.

Today, the fur industry plays an important role in the economies of many countries. Most of the world's fur supply comes from fur ranches, where fur-bearing animals are raised in pens. The rest comes from trapping wild animals. During the 1960's and 1970's, some wildlife protection groups and animal rights groups began to protest against the trapping of animals for fur. In the 1980's and 1990's, support for these groups has grown. They seek to protect many species of animals hunted for their fur from the threat of extinction. They also object to cruel methods of trapping and farming animals. One specific group, Lynx, was formed in October 1985 in Nottingham, England. One of their objectives is to discourage the fashion industry from promoting the wearing of animal fur.



Fur consists of long *guard hairs* and thick *underfur.* The guard hairs shed moisture, and the underfur keeps the animal warm.

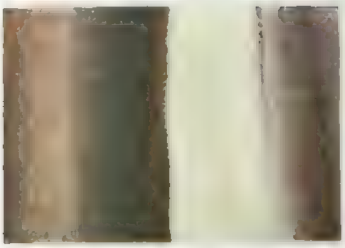
Russia produces more fur than any other nation. The United States ranks as the second largest producer, followed by Canada. Furs and fur garments have a high retail value. The fur garments produced annually in the United States, for example, have a total retail value of about $1\frac{3}{4}$ billion U.S. dollars. Fur products also form an important part of these countries' exports. Major importers of fur include France, Germany, Great Britain, Greece, Italy, Japan, Switzerland, and the United States.

Some important furs

Fur	Fur family	Animal's main habitat	Description
* **Beaver**	Rodent	North America	Dark brown; short, thick fur.
* **Chinchilla**	Rodent	Fur ranches	Blue-grey; long, branched, fine fur.
* **Coyote**	Dog	North America	Grey, yellow-grey, tan; long, thick fur.
Ermine	Weasel	Russia, North America	White, black; short, thick fur.
Fisher	Weasel	Canada	Dark brown; short, soft fur.
Fitch	Weasel	Europe	Yellow, beige, brown, black; long, silky fur.
* **Fox**	Dog	Asia, Europe, North America	Red, blue, silver, white; long, soft fur.
* **Lynx**	Cat	North America, Finland, Norway, Russia, Sweden	Beige, white; long, silky fur.
* **Marten**	Weasel	Asia, North America	Blue-brown; soft, thick fur.
* **Mink**	Weasel	Fur ranches, North America, Russia	Brown, grey, white; long, silky fur.
* **Mole**	Mole	Netherlands, Scotland	Blue, grey; soft, thick fur.
* **Muskrat**	Rodent	North America, Russia	Brown; long, silky fur.
* **Nutria**	Rodent	South America	Dark brown; short, soft fur.
* **Opossum**	Opossum	South America, United States	Creamy; short, rough fur.
* **Otter**	Weasel	North America, South America	Brown; short, thick fur.
Persian lamb	Sheep	Afghanistan, Kazakhstan, Namibia	Black, brown, grey; woolly, tightly curled fur.
* **Rabbit**	Rodent	Australia, Europe, Japan, North America	White, brown, grey; short, fluffy fur.
* **Raccoon**	Raccoon	North America	Silver grey, dark grey, black; long, coarse fur.
* **Sable**	Weasel	Canada, Russia	Dark brown; long, silky fur.
* **Seal**	Seal	Alaska, Canada, Namibia, Russia, Uruguay	Grey, salmon, silver, white; short, silky or stiff fur.
* **Skunk**	Weasel	North America	Black; long, silky fur.
* **Squirrel**	Rodent	Asia, Europe, North America	Grey; short, soft fur.

*Has a separate article in *World Book.*

Some kinds of fur



Mink ranges in colour from white to many shades of grey and brown.

Fox fur is long and soft. The most popular shades include red, white, and silver.

Muskrat fur is light brown. Some is dyed to resemble other kinds of fur.

Chinchilla is highly prized for its luxurious softness and unusual coloration.

Sable, one of the most beautiful and expensive furs, has a brown colour.

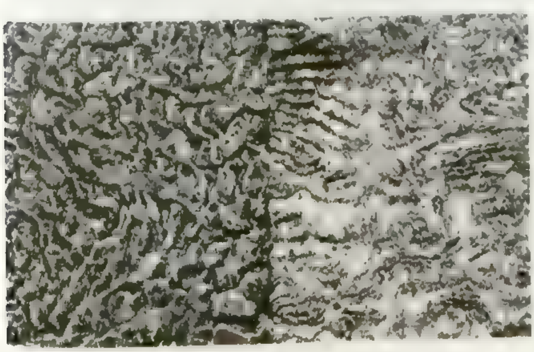
Beaver is prized for both its soft underfur, *left,* and its outer guard hair, *right.*

Kinds of fur

Natural fur. Popular natural furs used for clothing include beaver, coyote, fox, mink, muskrat, rabbit, and raccoon. Chinchilla, mink, Persian lamb, and sable are some of the most fashionable and expensive furs.

Furs differ greatly in colour, texture, and value. Colours range from jet-black to snow-white, with many shades of brown, blue, grey, red-orange, and tan. Fur texture varies from the velvety softness of beaver to the coarseness of raccoon. In the late 1980's, the price of a fur pelt in the United States ranged from about 1.00 U.S. dollar for a squirrel skin to about 1,700 U.S. dollars for a ranched sable from Russia.

Rodents provide more skins for furs than any other group of animals. Beavers, muskrats, and other rodents make up more than three-quarters of the total wild fur catch in Europe and North America. The weasel family supplies the greatest number of pelts from fur ranches. Weasels include ermines, minks, and sables.



Natural and artificial Persian lamb differ in appearance, as a close-up photograph shows. The natural fur is on the left.

Artificial fur consists of synthetic fibres that have been processed to look like real fur. Artificial furs serve as an alternative for people who choose not to wear natural fur. The most popular "fake furs" are imitation Persian lamb, mink, muskrat, and seal.

Manufacturers make artificial furs by weaving and knitting synthetic fibres into *pile fabrics.* Pile consists of soft, clipped fibre ends. Pile is treated to make it look like real fur. Natural fur fibres are sometimes woven into the pile to make it feel more like genuine fur.

How fur is obtained

Fur ranching. Millions of foxes and minks are raised yearly on ranches in the United States, Russia, Canada, and many European countries. Ranches in Afghanistan, Kazakhstan, and Namibia raise Karakul sheep, whose fur is called *Persian lamb* (see **Karakul**). Ranchers raise chinchillas in Europe, North America, Russia, South Africa, South America, and Zimbabwe.

The first fur ranches were established in the 1880's in Prince Edward Island, Canada. Today, fur ranchers conduct breeding programmes based on the principles of genetics. Skilled ranchers breed their animals to produce offspring of particular colours and sizes or with other special characteristics.

Trapping. Most fur trapping occurs in winter, when the furs are at their thickest, longest, and shiniest. Each trapper sets a series of traps called a *trap line* along riverbanks and at other locations that the animals visit frequently.

Some wildlife protection groups and animal rights groups oppose the trapping of animals for fur. These groups especially object to the use of *leg-hold traps.*

The jaws of such traps snap shut on an animal's leg and hold the animal until the trapper arrives to kill it. The U.S. and Canadian fur industries have worked to create more humane traps. *Padded traps,* also called *soft-catch traps,* have been developed. The jaw of such a trap, which grips the animal's paw, has a rubberized lining to prevent injury.

Government conservation programmes regulate fur trapping in every state of the United States except Hawaii, which has no fur-bearing animals. Government conservation programmes also operate in every Canadian province. Each state and province issues trapping licences and determines when and where trapping may take place. Regulations also set limits on the number of animals that may be trapped at one time. The United States and many other countries prohibit the import of furs of animals that are in danger of becoming extinct. These animals include cheetahs, leopards, tigers, and wolves. See **Wildlife conservation.**

Skinning. Two main methods are used for skinning animals—*cased* and *open.* Ermines, minks, and other small animals are skinned by the cased method. The rancher or trapper slits a line across the rump from leg to leg and peels the pelt off inside out. Beavers and other larger animals are skinned by the open method. A line is slit up the animal's belly and the pelt is peeled off from side to side. After removing the pelts, ranchers and trappers scrape them clean of all fat and tissue, dry them, and ship them to market.

Marketing fur

Most ranchers and trappers ship their furs to one of the great auction houses in the major fur-trading centres of the world. In the United States, the chief auction houses operate in Greenville, South Carolina; Minneapolis, Minnesota; New York City; and Seattle, Washington. Major Canadian auction houses are in Montreal; North Bay, Ontario; Regina, Saskatchewan; Vancouver, British Columbia; and Winnipeg, Manitoba.

Leading European fur auction centres include St. Petersburg, Russia; London; and Oslo, Norway. The Hudson's Bay Company in Canada is the world's largest fur-trading firm.

A mink rancher raises his animals in pens in a long barn. More than half the world's fur comes from animals raised on ranches

Representatives of auction houses visit trappers and ranchers to arrange the shipment of pelts to market. The largest cargoes of furs come to market from November to March. Fur dealers, manufacturers, and retailers attend the auctions. Buyers may examine several hundred thousand pelts in the warehouses on *examining days.* The furs are auctioned off on *sales days.* Buyers must pay for their purchases on or before the *prompt day,* which is usually about a month after the sales day. On the prompt day, the furs are shipped according to the buyers' instructions.

Processing fur

Dressing. Pelts bought at fur auctions must be cleaned and made flexible by a process called *dressing.* First, the pelts are softened in a salt solution that removes all excess tissue and grease. Excess skin that is still attached to the pelt is then removed, either by hand

Fur buyers inspect pelts at a fur merchant's storeroom and decide which ones to purchase. The storeroom contains pelts of various fur-bearing animals from many parts of the world.

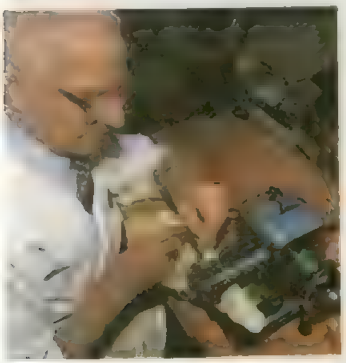
Pelts are matched according to colour, lustre, thickness, and other features. Matched pelts enable a manufacturer to produce a garment that has the same colour and texture throughout.

How a fur coat is made Making a fur coat requires the labour of many highly skilled workers. The illustrations below show some of the important steps involved in converting raw pelts into a finished garment.

Dressing includes the removal, by hand or by machine, of any bits of flesh that are still attached to the pelts.

Trimming. Workers trim off the heads, paws, bellies, rumps, and tails, which are used to make cheaper garments.

Letting-out is one of many techniques used by fur cutters. It involves cutting the pelts into long diagonal strips.



Sewing. An operator sews the strips together to form lengthened, narrow pelts. The pelts are sewn into a sheet of fur.

Blocking consists of shaping the sheet of fur by stapling it to a large board on which the coat pattern has been drawn.

Finishing. The sheet of fur is made into a coat, which is then cleaned. Finally, workers sew in the lining of the coat.

or by machine. Next, the processors apply a special grease to the leather and put the skins into a machine called a *kicker.* The kicker has wooden feet that pound the grease into every pore of a skin. The pelts are then placed in revolving drums, where they are cleaned and dried with special sawdust and compressed air. Later, the processors may pluck out the long guard hairs, leaving only the thick fur fibres. The fur may also be sheared shorter to give it a plush effect.

Dyeing. Many furs are dyed to improve their appearance or to make them look like other types of fur. Processors may put furs into a vat of dye, or they may dye entire coats by hand. Sometimes dark fur is bleached and then dyed a pale shade. In a special dyeing process called *tipping,* only the tips of the fur fibres are dyed. This process makes furs resemble darker pelts of the same variety. Tipping helps the manufacturer match several pelts to be used in the same coat.

Cutting and sewing. Furs differ in quality and appearance, and so manufacturers must carefully grade and match processed skins. A manufacturer makes the pattern for a garment and then selects the skins to be used. Workers stretch the skins and trim off the heads, paws, bellies, rumps, and tails. These parts are used to make cheaper garments.

A worker called a *cutter* trims and shapes the skins to make the best use of the material. An *operator* then sews the skins together to form a sheet of fur that approximately matches the shape of the pattern. Next, a worker called a *blocker* applies small amounts of water to the skin to make it stretch just enough to cover the edges of the pattern. Then the fur is *blocked,* or stapled, to a large pine board and left to dry. Later, any surplus material is trimmed from the skin and the fur is sewn into a garment. Finally, the garment is cleaned and the lining is sewn in.

Related articles in *World Book.* See the articles on the animals marked by an asterisk in the table *Some important furs* in this article. See also the following articles:

Animal (pictures) | Pribilof Islands
Astor (Family) | Trapping

Furfural is a liquid chemical that is used in many industries. Manufacturers use it in making nylon, plastics, and other products. Furfural changes from colourless to

The Furies were avenging goddesses in classical mythology. This painting shows them in a scene from a Greek tragedy by Aeschylus. They were usually shown with brass wings and snakes on their bodies.

Detail from Greek vase painting of the late 300's B.C.; The British Museum, London

yellow and finally dark brown when it is exposed to the air. Its vapour irritates the eyes, nose, and throat.

Furfural is used in the production of the chemical tetrahydrofuran (THF). Butadiene, a material used in *synthetic* (artificial) rubber, can be made from THF. THF is also used as a solvent to dissolve other substances in industry.

Furfuryl alcohol, another compound made from furfural, is used in making resins that protect metals from *corroding* (being eaten away). Many synthetic resins are made with furfural. Manufacturers use these synthetic resins to make plastic products. Because furfural kills various fungi, germs, and insects, it is used in fungicides, germicides, and insecticides. Rubber manufacturers use furfural to speed up the vulcanization process used to make rubber harder and more durable.

Chemists call furfural a selective solvent because it will dissolve some materials in a mixture and not others. Petroleum refineries use furfural to dissolve the harmful carbon and sulphur compounds found in impure lubricating oils. Furfural is also used to refine other petroleum products, such as diesel fuel.

Chemical manufacturers prepare furfural by mixing acid with waste plant materials such as maize stalks or the hulls of cottonseeds, oats, or rice. Furfural is also found in some natural oils. Johann Döbereiner, a German chemist, reported his discovery of furfural in 1832. He accidentally obtained the chemical by treating sugar with sulphuric acid and manganese dioxide. American chemists discovered the methods now used to manufacture furfural in the early 1920's.

Furfural is an organic chemical with the formula C_4H_3OCHO. It belongs to the aldehyde chemical family and is sometimes called *furfuraldehyde* (see **Aldehyde**). Furfural freezes at $-38.7°$ C and boils at $161.7°$ C. It is about 1.16 times as dense as water.

Furies were the terrible goddesses of vengeance in Roman mythology. The Greeks called them *Erinyes* or *Eumenides.* The Roman poet Virgil wrote of three Furies in his epic poem the *Aeneid.* He called them Alecto, Tisiphone, and Megaera. They carried whips and had snakes in their hair.

The Furies punished people for committing crimes. The Furies were especially vengeful against anyone who had killed a member of his or her family. In his tragedy *The Eumenides,* the Greek playwright Aeschylus describes how they drove Orestes insane for killing his mother, Clytemnestra.

See also **Orestes.**

Furlong is an English unit of measurement of length equal to 40 rods (220 yards), or about 200 metres. Furlong originally meant the length of one furrow in a ploughed field. This was indefinite because farmers ploughed many different lengths of furrows. Gradually the furlong became a standard length.

Among the Old English writers, the furlong was one-eighth of a mile in each of the world's different standards for a mile. In the 800's, the word meant the same as the Latin *stadium,* which was one-eighth of the Roman mile. The furlong is seldom used today except on racecourses. Many flat races are run over a 5 furlong or 7 furlong course.

See also **Weights and measures.**

Furneaux, Tobias (1735-1781), a British naval officer and explorer, sailed around the world with the explorer Samuel Wallis between 1766 and 1768. He then commanded the *Adventure,* which accompanied James Cook on the *Resolution* on his second voyage to the Pacific (1771-1775). After the ships were separated in the Southern Ocean, Furneaux sailed to explore Tasmania. He made the first British maps of the region, but failed to discover that Tasmania was an island. He also failed to reach the point where Cook had begun his earlier survey of New South Wales, Australia. After he rejoined Cook in New Zealand, both ships continued to explore the Pacific.

Well-designed furniture contributes beauty and comfort to daily life. The chairs, sofas, and tables in this living room reflect the clean, simple lines of modern furniture styles.

Furniture

Furniture consists of chairs, tables, beds, and other pieces that provide comfort and convenience in our homes, schools, and offices. We relax on chairs and couches, and we store various belongings in chests, dressers, and bookcases. Desks provide a place for study and paperwork. Some television sets and hi-fi systems have handsome cabinets, and so they also serve as pieces of furniture. In many homes, a piano is an impressive piece of furniture.

In addition to being useful, furniture is often designed to make our surroundings more pleasant. Furniture can work with other decorative and useful objects to beautify a room. Such items, including rugs and carpets, curtains, fabrics, lamps, and pictures, are called *soft furnishings.*

Most furniture is made of wood or wood products. But furniture makers also use glass, metal, plastics, and a variety of other materials. For example, office furniture, such as desks and filing cabinets, is designed to be practical and sturdy and is often made of steel.

Certain pieces of fine furniture are regarded as great works of art. Over the years, expert designers and *artisans* (skilled craftworkers) have created richly decorated furniture in various styles. Many of these artisans were regarded as artists equal to the most famous painters and sculptors of their day. Today, museums display examples of their furniture as masterpieces of art.

People who study the history of furniture have given names to the different styles. Some styles are named after important people. For example, Louis XIV furniture is named after King Louis XIV of France. Other styles, such as Regency, are named after historical periods or, as in the case of art nouveau, take their name from a movement in the history of art and culture.

The history of furniture can be seen as a series of styles that become popular for a time and then fall from fashion. Designers often revive earlier styles, adapting them to fit the taste of the time.

The history of furniture is closely related to the history of human culture. For thousands of years, all fine furniture was designed to accommodate the tastes of royalty and the nobility and other wealthy people. These people used furniture as a symbol of their power and rank rather than a practical necessity. Beginning in the A.D. 1500's, a middle class of people gradually developed in Western countries who wanted furniture that was comfortable and suited to their homes. By the 1800's, the tastes of middle-class buyers set the standard for furniture styles. Most furniture made today is designed to be practical, comfortable, easy to maintain, and cheap to produce. Much of it is fabricated in factories and large workshops that make use of the latest technology. And some furniture is available in the form of kits that can be assembled by the purchaser at home.

This article describes the history of furniture from its earliest period to the present time. For a discussion of the importance of furniture in interior decoration, see the *World Book* article **Interior decoration.**

Early furniture

The ancient Egyptians created the first known fine furniture in about 3000 B.C. Later, the Greeks and then the Romans developed outstanding furniture in their own characteristic styles. The age of Greek and Roman culture was followed in Europe by the Middle Ages, a period that in general produced little important furniture.

Ancient Egypt (3100 B.C.-1070 B.C.). The ancient Egyptians considered the ownership of furniture as a mark of social rank. The best-made and most beautiful furniture decorated the palace of the Egyptian *Pharaoh* (king). Members of the nobility, wealthy officials, and landowners also possessed fine furniture. The common people probably possessed little in the way of furniture in their simple homes.

Egyptian furniture makers did some of their best work in designing beds. Most beds had legs shaped like the legs of an animal, usually a lion. These beds led to the development of couches in the shape of an animal, such as a lion or a leopard.

Egyptian artisans also made fine chairs. The finest chairs had a seat of woven cord covered with a removable cushion. The development of the armchair was probably the most lasting Egyptian contribution to furniture design. Other Egyptian furniture included boxes, cabinets, and small tables.

Ancient Greece (about 1100 B.C.-A.D. 400). In ancient Greece, as in ancient Egypt, only persons of the highest social rank possessed much furniture. Most Greek citizens owned only stools and perhaps a crudely made table.

The Greeks borrowed many furniture forms, including the bed and the couch, from the Egyptians. Beds became major pieces of household decoration in ancient Greece because they were used for dining as well as for sleeping. During a meal, a person would lie on the bed on his or her side, leaning on one elbow for support.

Greek artisans produced a variety of forms of seating. The most important were the thrones made for people of high rank. Some thrones had a low back decorated with one or more carvings of animal heads. Others had a high back with flowerlike carvings. The arm supports were in the form of rams' heads. The most common type of Greek chair, called the *klismos,* had curved legs. The front legs curved forward, and the rear legs curved to the back.

The Greeks used tables more than the Egyptians did. Most Greek tables had three legs that ended in feet shaped like hoofs or paws. Greek artisans decorated the finest furniture with inlaid patterns of fine wood, silver, gold, and gems. They either carved ivory to form the feet or cast them in silver or bronze.

Ancient Rome (700's B.C.-A.D. 400's). The Romans borrowed many furniture forms from the Greeks but gave them a distinctly Roman character. For example, the Romans used more bronze and silver in their furniture than did the Greeks. The Romans used the Greek klismos but made it heavier and larger. They also covered it with upholstery. Roman furniture makers adopted a Greek stool design and developed it into a stool called a *curule.* The curule had two pairs of legs.

Egyptian Museum, Cairo, Egypt

An ancient Egyptian throne, *above,* which belonged to King Tutankhamen, is decorated with carvings of lion heads and paws.

Relief from a gravestone (about 400 B.C.); Archaeological Museum, Athens, Greece

A common ancient Greek chair was the *klismos, left.* Such chairs had curved legs and a curved back.

A reconstructed Roman stool called a *curule, below,* has curved legs in the shape of an X.

Rijksmuseum, Nijmegen, the Netherlands

A simply built chest, *right,* is typical of the furniture of the Middle Ages. Carvings were a common form of furniture decoration during this period.

Church of St. Mary, Stoke D'Abernon England

The delicate, curved legs in each pair were crossed in the form of an X.

Tables were very popular among the Romans. Many tables had three or four legs connected by crossbars. The *slab table* was a major Roman contribution to table design. The tabletop consisted of a large slab of marble or wood, which rested on carved upright marble slabs. Artisans sculptured various designs into the upright slabs, including animals, flowers, fruits, and vines.

The Middle Ages (400's-1300). During the period of European history called the Middle Ages, skilful furniture making generally became a lost art. Most furniture of the Middle Ages was coarse and unrefined by the standards of ancient Greece and Rome. Furniture makers painted or *gilded* (coated with gold) most pieces to disguise their crude construction. As in earlier times, people of high rank owned the best furniture.

Landowners and church officials of the Middle Ages travelled frequently. They usually took their furniture and other possessions with them on their journeys. Much furniture was therefore designed to be portable. Large pieces were put together in such a way that they could be taken apart and carried easily. Chests were used for storage as well as for seats.

During the 1200's, a new Western European art style called *Gothic* influenced the design of furniture. Artisans decorated their furniture, especially chests and cupboards, with arches, columns, and other features of Gothic architecture.

Oriental furniture

In the Oriental countries, as in Egypt and Europe, only high-ranking officials and wealthy people owned finely crafted furniture. The artisans of China, Japan, and India produced the most noteworthy Oriental furniture. The earliest high-quality Oriental furniture was produced in China during the 200's B.C.

China. By the time of the Han dynasty (202 B.C.-A.D. 220), the Chinese had developed several furniture forms. The most characteristic was the *kang,* a platform on which a person could lie to sleep or rest. The Chinese of this period grouped a variety of small stools and tables around the kang.

Later Chinese furniture falls into two categories: household furniture and the furniture used in royal palaces. Chinese household furniture was simple and practical. Palace furniture was larger, heavier, and more richly decorated than household furniture.

A notable characteristic of all Chinese furniture was the skilful manner in which artisans joined the parts. They used no pegs or nails and seldom used glue. Instead, they carved the edges of parts so expertly that the parts fitted together tightly.

By the early 1400's, the Chinese were using low dining tables supported by gracefully curved legs now known as *cabriole* legs. A cabriole leg has S-shaped curves, and it ends with a decorative foot. Beginning in the 1700's, this design became an important feature of Western furniture and was given the French name *cabriole.* The best-known Chinese chair design had a single vertical *splat*—a piece of wood that formed the centre of the chair's back.

Chinese dining tables of the 1400's had curved legs that became known as *cabrioles.* This table is 30 centimetres high

A typical Chinese chair of the 1500's had a single vertical *splat* that formed the centre of the chair's back.

A Japanese cabinet of the early 1600's is made of lacquered wood. The doors and shelves have grapevine designs.

Japan. Japanese architectural styles largely determined that country's furniture styles. Earthquakes occurred frequently in Japan, which resulted in the building of light, one-storey buildings. In both homes and palaces, the Japanese used small, lightweight cabinets, chests, and writing tables rather than large, heavy pieces. The Japanese customarily sat and slept on floor mats, and so they used no chairs or beds. Their furniture was simple in shape, but it was beautifully decorated with colourful designs of flowers, animals, and scenes from Japanese literature. Japanese artisans lacquered the furniture to give it a glossy finish. This use of lacquer gave the furniture a distinctive quality. Japanese furniture makers also beautified their work with shell inlays and rich fabrics.

India. The earliest important pieces of Indian furniture were chairs designed to be used by members of the nobility. Such thrones later developed into four-legged platforms on which a person sat with legs folded. Many of these thrones had the shape of a flower blossom. A person sat on cushions and used pillows for a backrest. Indian beds were covered with luxuriously upholstered cushions and mattresses.

An Italian Renaissance chest called a *cassone, above,* is made of fine wood and beautifully carved. Such chests were the most popular type of furniture in Italy during the Renaissance.

The Renaissance

The Renaissance was a period of European history that lasted from about 1300 to 1600. A major characteristic of the period was a revival of interest in *classical* cultures—that is, the cultures of ancient Greece and Rome. Classical art thus had a strong influence on furniture designed during the Renaissance. Italian artisans created the first important Renaissance furniture. Their work attracted much attention in other European countries, especially France, England, and Spain.

Italy. During the Renaissance, the palaces of Italian nobles became famous for their luxurious interiors, which included fine furniture and magnificent paintings. Actually, these palaces contained few pieces of furniture by today's standards. The best-furnished room in a palace was the *studio,* a library in which the owner kept books, manuscripts, gems, medals, and small sculptures. These items rested on shelves in beautifully ornamented cupboards.

Chests continued to be important articles of furniture, as they were in the Middle Ages. During the early 1500's, a large type of chest called a *cassone* was carved, gilded, and painted with scenes from classical history and mythology. A new form of chest called the *cassapanca* developed from the cassone. The cassapanca had a backrest and arms, and it was used as a sofa as well as a chest. Large cupboards called *sideboards* or *credenzas* became popular pieces of Italian furniture. Artisans decorated them with columns and other features of classical architecture.

France. French Renaissance furniture can be divided into two important styles, called Francis I and Henry II. Each style was named after a French king. Francis I ruled from 1515 to 1547. Henry II ruled from 1547 to 1559.

Before the reign of Francis I, French furniture reflected the Gothic style of the late Middle Ages. A new style developed after Francis brought leading Italian artists to France to remodel the royal *château* (castle) at

Château de Beauregard, Blois, France

A French Renaissance cabinet, *above,* was designed in the Henry II style, which became popular during the mid-1500's. Such cabinets had a small upper section that rested on a larger base. Furniture makers decorated these pieces with carvings of human figures and scenes from Greek and Roman mythology.

English furniture of the Renaissance was solid and sturdy, as this picture indicates. The picture shows the drawing room of Hardwick Hall, an English estate, as it looked in the 1590's. The room has a new and distinctly English furniture form, a dining table called a *draw-table, foreground.* The length of the table could be increased by drawing its halves apart and adding leaves. Carvings of mythical winged beasts support the tabletop.

Fontainebleau. In redesigning the château, the Italian artisans introduced decorative *motifs* (designs) that revolutionized French art of the period. These motifs included the use of columns; carved human heads surrounded by scrolls; carved bands, called *strapwork,* which imitated tooled leather bookbindings; and *niches* (hollowed-out areas in walls).

The Italian-inspired Francis I style of furniture lasted until the mid-1500's. The Henry II style, which was more varied and more identifiably French, then replaced it. Carved human figures still played an important decorative role, as did carved animals. Columns and arches served as supports for tables. But the new style gave furniture a lighter appearance. For example, French artisans refined the traditional cabinet form by placing a small upper section on a larger base.

England. The Italian Renaissance influenced England largely because of the encouragement of King Henry VIII, who ruled England from 1509 to 1547. Henry invited Italian artists and artisans to work in England. English furniture makers then blended the Italian ornamental style with traditional English designs to create an English Renaissance style.

A number of distinctly English furniture forms appeared during the reign of Queen Elizabeth I, who ruled from 1558 to 1603. One of these forms was the *draw-table,* a large oak dining table made in halves that could be drawn apart. The length of this table could be increased by adding one or two top sections called *leaves* after drawing the halves apart. Another fashionable English design was the *court cupboard,* which had open shelves for displaying valuable plates and silverware. The cupboard had legs that were decorated with classical and Italian Renaissance motifs. Perhaps the most impressive pieces of English Renaissance furniture were beds, which featured handsome carvings and expensive fabrics.

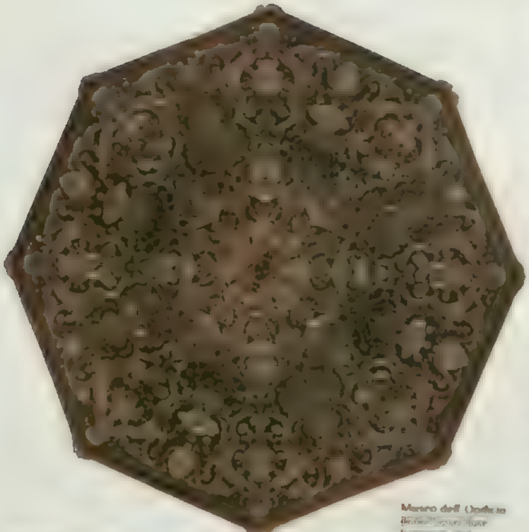
Spain developed a Renaissance style that combined Spanish, Italian, and Moorish influences. The Moors were North African Muslims who had invaded Spain in the A.D. 700's. The Moorish impact on Spanish furniture appeared in an emphasis on gilding and the use of geometric designs that were made with ivory and wood inlays.

A major contribution of Spanish artisans was the design of a portable cabinet called a *vargueno.* The vargueno's door was hinged at the lower edge. When opened, the door served as a writing desk. The vargueno had many small drawers and a central cupboard.

Art Institute of Chicago

A portable cabinet called a *vargueno* was a contribution of Spanish artisans. Varguenos had a door that could serve as a desk. This vargueno, made about 1600, rests on another cabinet.

The 1600's



Museo dell' Opificio [illegible]

An Italian tabletop of the 1600's is decorated with semi precious stones in a technique called *pietre dure*. Other popular tabletops of the period were made of marble or inlaid wood

The early 1600's were years during which most of Europe was engaged in political and religious wars. This warfare hindered the development of the arts in many European countries. Only Italy and the Netherlands enjoyed peace, and Italian artisans especially became an important source of new furniture design. Dutch furniture makers achieved excellence in creating beautiful floral designs with inlays of tropical woods and *mother-of-pearl* (the lining of certain sea shells.

In France, King Henry IV established royal furniture workshops in the Louvre in Paris. He financed the workshops and brought leading artisans from other countries to work in them.

Italy led in furniture development largely because many rich Italian merchants were building great palaces during the period. The merchants wanted the finest furniture for their palaces, and Italian artisans supplied it.

Many Italian tables had a base modelled on the slab tables of ancient Rome. Other tables had a top made of marble or inlaid wood on a base sculptured in the form of mythical creatures, shells, floral designs, and human figures. Sculptured human figures also supported cabinets, candlestands, and some chairs.

Italian artisans created fashions for chests, cabinets and cupboards that spread throughout Europe. The cassone of the 1500's developed into a long credenza with a number of doors. The credenza, in turn, gradually

Château of Vaux-le-Vicomte (1661) near Melun, France

The Louis XIV style was known for its luxury. Louis Le Vau, the French architect who designed this room, combined beautiful furniture with works of art and architectural decorations to achieve an elegant effect. The sofa and high-backed chairs are typical of the Louis XIV style.

State beds, which featured a [illegible] canopy and [illegible] curtains, were important pieces of furniture among the nobility and the wealthy during the late 1600's. Daniel Marot, an influential French [illegible] maker, designed this state bed for the royal bedroom in Hampton Court Palace, near London.

developed into two new forms. One form was a tall two door cabinet. The other was a tall chest of drawers that rested on a stand.

Many people of the early 1600's considered the quality of upholstery to be a measure of a householder's social rank. As a result, beds—which were richly decorated with silk, velvet, and other luxurious fabrics—became major pieces of furniture. Such large *state beds* were placed in the main room of a palace or large house as well as in the bedrooms.

Louis XIV furniture was the most notable furniture of the late 1600's. Louis XIV had become king of France in 1643, when he was only 4 years old. He took control of the French government in 1661, after the death of France's chief minister, Jules Cardinal Mazarin. Louis, who was then 23 years old, devoted himself to making France the cultural and political centre of the Western world. He considered furniture making and the decorative arts to be politically important because he could use them to glorify his position as king. He bought a building on the outskirts of Paris, turned it into workshops and staffed the shops with expert artisans. He commissioned them to create furnishings for his residences. These furnishings created a new national style of art.

Actually, the artisans worked almost entirely on a single project in Versailles, where they converted a royal hunting lodge into a luxurious royal palace. The noted French architect Charles Le Brun supervised the huge Versailles project and hired artisans from other countries. The decorating and furnishing of the Versailles palace became such a large undertaking that many foreign artisans took up permanent residence in France. Many of them married French women and had children who became furniture makers, creating a native French group of artisans.

The remarkable style of the furnishings made for the Versailles palace became known as the *Louis XIV* style. This luxurious style was particularly notable for two important characteristics. One was a *veneer* technique invented by a French cabinetmaker, Andre Charles Boulle. In this technique, artisans "sandwiched" a *veneer* (thin layer of material) between two veneers of a contrasting material. Artisans used such materials as brass, ebony, pewter, and tortoiseshell. They cut through the layers to create contrasting scrolled patterns. Veneers were applied to Louis XIV cabinets, writing tables, and other furniture. Le Brun and Louis himself were responsible for the second characteristic—*repousse* furniture of inlaid silver made for the main rooms at Versailles.

The French influence spreads. The furnishings of the Versailles palace set the standard for other royal palaces, and soon French styles were imitated in palaces throughout Europe. But there were also political and religious reasons for the spread of French influence.

The national religion of France was Roman Catholicism, but most French artisans were Protestants. The French Protestants, called *Huguenots,* enjoyed religious freedom under the Edict of Nantes, which was issued by King Henry IV in 1598. In 1685, Louis XIV took away the Huguenots' freedom by cancelling the edict. Most of the artisans then fled to the Netherlands or to England. There, they worked among the nobles and wealthy merchants and so established a taste for French design in the two countries.

Daniel Marot became one of the most influential Huguenot artisans both in the Netherlands and in England. Marot worked for William III, who was a Dutch prince before he became king of England in 1689. Marot also designed the interiors and furniture for Hampton Court Palace, near London. His designs created a demand in the late 1600's for high-backed chairs with French-style upholstered seats and backs. Marot's work also led to a fashion for state beds with drapery even more luxurious than that used in France.

The 1700's

A low chest of drawers called a *commode* became a popular furniture form of the 1700's. The commode above has curves of bronze. Curved decorations were basic to the *rococo* style of the early 1700's.

The French neoclassical style of the late 1700's, *right,* featured light, graceful furniture with straight lines. The influence of ancient Roman art can be seen in the decorations on the furniture and walls.

Queen's Salon (1781), Versailles, France

Artisans in France and England dominated furniture design during the 1700's. Furniture makers in other countries interpreted the French and English designs and developed them into individual national styles.

French styles

The Régence Style of the early 1700's received its name because a *regent* (temporary ruler) governed France during the period. After Louis XIV died in 1715, his 5-year-old grandson became King Louis XV. Because of the king's youth, his uncle, the Duke of Orleans, was appointed regent. The duke disliked the formality of the luxurious palace at Versailles and moved the royal court to Paris. There, a less ceremonial life style developed among the people of the court. They lived in residences called *town houses,* which were smaller and more intimate than the palace at Versailles. The style of furniture created for these town houses became known as the Régence style.

Régence furniture had a lighter, more graceful quality than Louis XIV furniture, emphasizing curves and delicate floral designs. Perhaps its most important characteristic was the use of the cabriole leg, which was inspired by Chinese furniture.

During the Régence period, the French cabinetmakers André Charles Boulle and Charles Cressent developed a low chest of drawers called a *commode.* This form became one of the most popular of the 1700's and was made with regional variations throughout Europe

The rococo style. During the 1730's, the Régence style took on the features of a new style called *rococo.* The leading designer of rococo furniture was Juste-Aurèle Meissonnier. His motifs stressed swirling curves, *asymmetrical* (irregular) designs, and carvings of rocks and shells. The name *rococo* comes from the word *rocaille,* used to describe the rock-and-shell designs. The rococo style was also called the *Louis XV* style.

European Room by Mrs. James Ward Thorne, Art Institute of Chicago

French provincial furniture was a comfortable style favoured by middle-class people in the French provinces. This bedroom of the 1700's includes a tall cupboard and a bed set into the wall

Rococo furniture was designed to blend with the overall architectural plan of a room. For example, artisans designed tables, mirrors, benches, and beds so that they could be set into wall niches provided by the architect. Chairs were made and painted to look as though they were all in one piece, with no visible joints. Oriental furniture styles also influenced rococo design. A style called *chinoiserie,* loosely based on Chinese motifs, became especially popular. Oriental lacquer also became fashionable.

The neoclassical style, called the *Louis XVI* style in France, had replaced the rococo style by the late 1750's. The word *neoclassical* is a combination of the prefix *neo,* which means *new,* and the word *classical.* Neoclassical design thus reflected a renewed interest in the furniture motifs of ancient Greece and Rome. Neoclassical designers gradually eliminated the numerous curves of the rococo style in favour of the straight outlines of classical furniture. In place of elaborate rococo decorations, neoclassical artisans used thin pieces of plain wood arranged in geometric designs.

Much neoclassical furniture was inspired by classical motifs that were discovered in the mid-1700's by archaeologists in two ancient Roman cities, Pompeii and Herculaneum. The cities had been buried by an eruption of the volcano Mount Vesuvius in A.D. 79.

Art Institute of Chicago

The Queen Anne style of the early 1700's featured splat-backed upholstered chairs and large desks called *secretaries.* The style introduced the cabriole leg into English furniture.

Art Institute of Chicago

The Chippendale style dominated English and American furniture of the mid-1700's. The three chairs in the room shown above have carved mahogany legs, which are characteristic of the style. The influence of Chinese furniture design appears in the splat-backed chair on the left.

Dining room at Osterley Park House, London (about 1770)

The English neoclassical style was begun by Robert Adam, a Scottish architect, in the 1760's. His light, harmonious designs can be seen in this dining room. A mirror in a richly carved frame hangs above a table called a *sideboard.* Moulded plaster ornaments decorate the walls and ceiling.

English styles

The Palladian style was popular in England during the early 1700's. It was named after Andrea Palladio, an Italian architect of the 1500's. English artisans adopted elements of Palladio's style, which was based on the style of Roman architecture. For example, they decorated chests and cupboards with such architectural features as columns, ornamental mouldings called *cornices,* and triangular top sections called *pediments.*

Henry Francis DuPont Winterthur Museum, Wilmington, Delaware, U.S.A.

Early American furniture was simple and sturdy. Most of the designs were based on English styles. The room on the left dates from about 1670. The cupboard, with its open shelves and a closed cabinet, reflects the influence of a type of English furniture called a *court cupboard.*

The Queen Anne style. The Palladian style was so expensive to produce that only wealthy people could afford it. The English middle class used a less expensive and more comfortable-- style. It was called the Queen Anne style after the queen who ruled England from 1702 to 1714. The Queen Anne style introduced the cabriole leg into English furniture design.

Chippendale furniture. In 1754, the English cabinetmaker and furniture designer Thomas Chippendale published a book of furniture designs called *The Gentleman and the Cabinet-Maker's Director*. It was the first book dealing entirely with furniture to be published in England, and it had a tremendous influence. In the book, Chippendale did not introduce any new styles. But he portrayed existing styles, especially the rococo, with such freedom and vigour that his designs were widely copied. His influence became so widespread that the name Chippendale has come to mean almost any English or American rococo furniture of the mid-1700's.

English neoclassical furniture. Robert Adam, a Scottish architect and furniture designer, introduced the neoclassical style into England in the 1760's. Adam borrowed some of his ideas from the French neoclassical style, but he also contributed many original elements. For decoration, he used delicate floral motifs, ram and ox heads, and other features inspired by ornaments on Roman buildings and tombs. Adam introduced the sideboard, or credenza, into English furniture. He also became known for skilfully blending furniture into the architectural plan of a room

A number of English furniture makers adopted Adam's neoclassical style during the late 1700's. Two of the best known, George Hepplewhite and Thomas Sheraton, prepared design books that popularized the style The furniture made according to Adam's original designs was very expensive. Hepplewhite, Sheraton, and other furniture makers simplified the designs to reduce the cost of the furniture for middle-class buyers.

Early American furniture

In the English colonies of North America, furniture design generally reflected the styles that were popular in England at the time. However, colonial artisans developed variations of the English styles. Starting about 1790, the most common early American style was a neoclassical variation called the *Federal* style. This style took its name from the young nation's new federal form of government. Duncan Phyfe, the leading American furniture designer of the period, worked in New York City. High-quality furniture was also produced by artisans in Boston, Massachusetts; Philadelphia, Pennsylvania; and Newport, Rhode Island.

Henry Francis DuPont Winterthur Museum, Wilmington, Delaware, U.S.A

The Federal style of American furniture began about 1790. It was influenced by the straight lines of English neoclassical furniture. The pieces in the bedroom shown above were largely based on designs by such English furniture makers as George Hepplewhite and Thomas Sheraton.

The 1800's

Until the early 1800's, furniture fashions were set largely by the tastes of nobles and other wealthy people. But beginning in the early 1800's, the tastes of the middle class set the standard for furniture fashions. People of the middle class wanted variety and novelty in furniture design. As a result, a great number of styles became popular for a short time and were then replaced by new styles.

During the 1800's, many furniture expositions were held in major cities in Europe and the United States. At these expositions, furniture makers from many countries displayed their own designs and viewed the designs of others. These designs greatly influenced public taste. The expositions thus had the effect of establishing international furniture styles. The same major styles, with some regional differences, were adopted in many European countries, the United States, and elsewhere.

The furniture of the 1800's falls into two categories: (1) furniture based on historical styles and (2) furniture intended to be truly original. Some furniture makers simply copied earlier styles. Others used earlier styles as models but changed them to give them freshness and new vigour. The invention of new furniture-making machines during the 1800's helped designers develop new styles. With these machines, designers could use materials in new ways. For example, they could use such materials as cast iron and wire in ways that had formerly been impossible.

The Empire style, the first major style of the 1800's, originated while Emperor Napoleon I ruled the French empire. Like Louis XIV, Napoleon wanted to use furniture as a symbol of political greatness. As a result, Empire furniture was impressive—large and heavy.

Empire artisans borrowed designs from Egyptian, Greek, and Roman furniture. They made chairs with curved rear legs shaped like those on the Greek klismos. They decorated furniture with such classical subjects as lions, sphinxes, and sculptured female figures called *caryatids.* Empire commodes, writing tables, and desks called *secretaries* were designed to fit into the overall plan of a room.

The Regency style, a neoclassical style, was fashionable in England and the United States along with the Empire style. The Regency style was named after the period from 1811 to 1820, when the Prince of Wales served as regent for King George III of England. Most Regency furniture combined Egyptian, Chinese, and Gothic motifs with neoclassical elements. The style featured couches with ends shaped like scrolls, and chairs loosely modelled on the klismos. Stools based on the Roman curule also were popular.

Regency artisans used little carved ornamentation. They often used a decorative technique called *penwork,* in which artists inked designs on light-coloured wood or a painted white surface. Regency artisans also decorated furniture with brass inlays.

The Biedermeier, or Restoration, style. After the fall of Napoleon I in 1815, the majestic Empire style went out of fashion. A more informal style favoured by middle-class people replaced it. This new style was called either by its German name, *Biedermeier,* or by its French name, *Restoration.* The name Biedermeier comes from a comic character in German popular literature (see **Biedermeier**). The term Restoration refers to the restora-

An Empire-style dressing table, *above,* features a round mirror and built-in candleholders. The table also has a marble top and curved, crossed legs like the legs of the Roman curule.

Art Institute of Chicago

Biedermeier furniture of the early 1800's had an informal, practical style. The chair and drop-front desk shown above illustrate the appealing simplicity of the style.

tion of the French monarchy after the fall of Napoleon's empire. The style produced comfortable, practical furniture that had simple lines and simple decoration. The most important forms were desks, display cabinets, small work tables, and pianos.

Historical revivals. From the 1830's to the late 1800's, a number of earlier styles were revived. The most important styles, in the order in which they appeared, were the Gothic, rococo, and Renaissance revivals. People sometimes used each style in a particular room. They might have placed Gothic furniture in the library, rococo in the *drawing room* (living room) and bedroom, and Renaissance in the dining room.

Most Gothic revival furniture consisted of neoclassical forms with Gothic ornaments. These ornaments included pointed arches and decorative patterns called *tracery*. The style was particularly popular in England, where a variation called the *Elizabethan revival* became fashionable. In France, Gothic revival was known as the *cathedral* or *troubadour* style.

The rococo revival replaced the Gothic revival in the 1840's. Chairs and sofas in this style had cabriole legs and oval backs based upon the Louis XV style of the 1700's. Artisans decorated pieces with rocaille carving and introduced large pieces, such as mirrored wardrobes, sideboards, and display cabinets. Such pieces remained popular throughout the 1800's.

The Renaissance revival began in the court of the French emperor Napoleon III, who ruled from 1852 to 1870. It achieved its greatest popularity in the late 1870's and the 1880's. Artisans of this period tried to reproduce the furniture designs of the 1400's and 1500's. Designers emphasized angular forms and richly upholstered chairs, sofas, and stools.

Art nouveau was an art movement that developed as a revolt against the historical revival styles. It began in the 1800's and lasted until the early 1900's. Art nouveau furniture featured design elements based on natural forms, such as blossoms, roots, stalks, and vines. Designers combined these forms with a graceful motif called a *whiplash* curve. Art nouveau decorations often included female heads surrounded by flowing hair.

Middle-class buyers could not afford the handmade and expensive art nouveau furniture. After wealthy buyers tired of the style's specialized designs, it fell from fashion. But the popularity of art nouveau and its rejection of traditional styles greatly contributed to design developments in furniture of the 1900's.

Living room furniture in the rococo revival style, *above,* has cabriole legs and oval backs edged with fine wood carvings.

Musee de l'Ecole de Nancy, Nancy, France

Art nouveau was a decorative style characterized by a graceful curve known as a *whiplash* curve. This feature appears in both the furniture and the wall and ceiling decorations in the dining room shown on the left.

The 1900's

During the 1900's, many designers have rejected traditional furniture styles. The designers of this period have made use of new manufacturing methods and new materials to revolutionize both the appearance and the function of furniture.

A variety of modern furniture styles has appeared during the 1900's, but most of the styles share a number of characteristics. The chief characteristic of modern furniture is its *abstract* form—that is, its appearance is not based on traditional designs using animals or human figures. Most modern furniture has little decoration. Designers have used as few materials as possible and have selected materials that are lightweight, hard, and smooth. They have also reduced the number of parts in a piece of furniture. For example, modern tables and chairs may have only one support instead of the traditional four legs. Such reductions in materials and parts have made manufacturing simpler and less costly.

Modern designers have also reduced the number of furniture forms used in a room. For example, some designers have eliminated traditional cabinets and cupboards and replaced them with sets of drawers and shelves called *storage units*. Some storage units are built into walls and become part of a room's architecture. Others are *modular units*, which can be moved and combined in various ways to fit a particular setting or to rearrange space within an area.

Early styles

De Stijl (The Style) was an art movement that began in the Netherlands in about 1917. Led by the Dutch architect and furniture designer Gerrit Rietveld, the De Stijl movement produced furniture that emphasized abstract, rectangular forms. Rietveld used only the three primary colours—blue, red, and yellow. The pure geometrical forms of De Stijl furniture and the lightness and clarity of the design influenced most later styles of the 1900's.

The Bauhaus was a school of design founded by the German architect and educator Walter Gropius in 1919. Perhaps the most important Bauhaus contribution to furniture design was the development of the use of *tubular steel*. Tubular steel is steel tubing that can be bent and shaped to form furniture frames and supports. This use of tubular steel reduced the number of expensive joints in a piece of furniture and the amount of upholstery needed to cover the piece.

Marcel Breuer, a Bauhaus instructor, introduced tubular steel in his *Wassily* chair in 1925. Breuer made this light, elegant, and comfortable chair of chrome-plated tubular steel and canvas. In 1929, Ludwig Mies Van der Rohe, a director of the Bauhaus, created his famous *Barcelona* chair of curved steel bars and leather cushions. The chair's curved, X-form legs recalled the style of the curule stools of ancient Rome.

Organic design is the name often given to the work of the American architect Frank Lloyd Wright. Wright believed that furniture should fit naturally into its surroundings. Like other pioneers of modern furniture design, Wright reduced his forms to basic geometric outlines. But, unlike De Stijl and Bauhaus furniture, which could be used interchangeably in most homes or offices, each piece of Wright furniture was an original design intended to blend into a specific setting.

Art deco was a popular art movement during the 1920's and 1930's. It showed the influence of art nouveau but eliminated the curves and naturalistic carvings common in that earlier style. Art deco designers created streamlined shapes that stressed geometrical proportions and emphasized the fine quality of the materials.

The David and Alfred Smart Gallery, University of Chicago

Organic design—a creative technique promoted by the American architect Frank Lloyd Wright—results in furniture that closely matches its architectural setting. The photograph on the left shows the dining room furniture Wright designed for his famous Robie House, which was built in Chicago in 1909.

Classics of modern furniture design

The chairs shown below rank among the furniture masterpieces of the 1900's. Their designs, as in Mies Van der Rohe's Barcelona chair and Eero Saarinen's tulip chair, have a light, airy appearance that is typical of most modern furniture. The caption beneath each picture gives the name of the designer, the date the chair was created, and the chair's most important materials.

Gerrit Rietveld (1917)
Painted wood

Marcel Breuer (1928)
Cane and steel tubing

Mies Van der Rohe (1929)
Steel and leather

Alvar Aalto (1934)
Moulded plywood

Charles Eames (1946)
Plywood and metal

Hans Wegner (1949)
Wood and cane

Harry Bertoia (1952)
Metal rods and wire

Eero Saarinen (1957)
Plastics and aluminium

Unlike most other modern styles, which were undecorated, art deco used various decorative motifs, notably lightning bolts, wheels, circles, pyramids, and waterfalls.

Modern Scandinavian design originated in the 1920's in the Scandinavian countries—Denmark, Sweden, and Norway—and in Finland. Kaare Klint, a Danish architect, is considered the first of several leaders of the modern Scandinavian style. Most Scandinavian furniture was made with native hardwoods, notably birch. The use of wood gave the style a warmer, more natural quality than modern furniture that relied on steel.

Recent developments

The United States became a major furniture design centre during the 1940's, largely through the activities of the Museum of Modern Art in New York City. In 1940, the museum established a department of industrial art, which held furniture exhibitions and sponsored competitions in furniture design. Several of the designs entered in these competitions had great international impact. The museum brought worldwide attention to many American designers, notably Charles Eames and Eero Saarinen. Many experts consider Eames the first internationally important American furniture designer.

In 1940, Eames and Saarinen won a museum competition for their design for an armchair. The arms, back, and seat of the chair were joined in one moulded plywood form. In 1946, Eames designed a chair in which the plywood seat was attached to a thin frame of chrome-plated rods by rubber discs. The discs allowed the parts of the chair to shift with the weight of the sitter, thus providing extra comfort. In 1957, Saarinen created the *tulip suite,* a cluster of curved chairs and a table, all made of fibreglass and mounted on single, slender aluminium supports. The suite consisted only of chairs and a table because Saarinen wanted to eliminate other forms of furniture.

During the 1900's, large companies have been formed that design and manufacture furniture. One of the most famous is Knoll International, founded in New York City in 1938 by Hans Knoll. This company produces furniture created by many leading modern designers. A famous British name in furniture design and manufacture is Habitat, which was established in London's Fulham Road in 1964.

Although designers and manufacturers of the 1900's have revolutionized furniture, most buyers still purchase furniture made in traditional styles. The French and Eng-

lish styles of the 1700's and 1800's are especially popular and are still manufactured by modern furniture makers. Owing to a reduction in the supply of high-quality timber, much contemporary wood furniture is manufactured using a combination of wood and cheaper materials such as plywood and chipboard. Wood surfaces are often a thin veneer laid over the less expensive material. Some modern veneers are made of plastic or are plastic-covered wood. More complicated or expensive furniture, however, is still stained and varnished by hand.

Study aids

Related articles in ***World Book*** include:

Biographies

Chippendale, Thomas
Eames, Charles
Hepplewhite, George
Morris, William
Phyfe, Duncan
Sheraton, Thomas

Styles

Art deco
Art nouveau
Bauhaus
Biedermeier
France (picture: Historic French furniture)
Rococo
White House

Other related articles

Antique
Architecture
Art and the arts (picture: The useful arts)
Bed
Inlay
Interior decoration
Ironwork, Decorative
Lamp
Mahogany
Mount Vernon
Museum (picture)
Shakespeare, William (picture: A bedroom in the Birthplace)
Wicker
Wood

Outline

- **I. Early furniture**
  - A. Ancient Egypt
  - B. Ancient Greece
  - C. Ancient Rome
  - D. The Middle Ages
- **II. Oriental furniture**
  - A. China
  - B. Japan
  - C. India
- **III. The Renaissance**
  - A. Italy
  - B. France
  - C. England
  - D. Spain
- **IV. The 1600's**
  - A. The early 1600's
  - B. Louis XIV furniture
  - C. The French influence spreads
- **V. The 1700's**
  - A. French styles
  - B. English styles
  - C. Early American furniture
- **VI. The 1800's**
  - A. The Empire style
  - B. The Regency style
  - C. The Biedermeier, or Restoration, style
  - D. Historical revivals
  - E. Art nouveau
- **VII. The 1900's**
  - A. Early styles
  - B. Recent developments

Questions

What was a *klismos*? A *curule*?
Who was the leading designer of the Federal style in American furniture?
How did the Bauhaus influence furniture design in the 1900's?
What is a *cabriole* leg?
How did classical art influence Italian Renaissance furniture?
What were the two main characteristics of the Louis XIV style?
How did Japanese architecture influence Japanese furniture?
What were some characteristics of the Regency style? The Régence style?
Who was Kaare Klint? Eero Saarinen?
How did the rococo style differ from the neoclassical style?

Furniture making often requires much handwork in addition to work done by machines. This worker applies a colouring substance to get a matching finish on all parts of a chest.

Furphy, Joseph (1843-1912), was one of the most original novelists in Australia at a time when strongly nationalistic themes were prevalent in literature. Under the name of *Tom Collins* or *Warrigal Jack,* he contributed anecdotes to *The Bulletin* (see **Bulletin, The**). Tom Collins is the narrator of Furphy's most famous book, *Such Is Life,* published in 1903. The book shows Furphy's varied experiences as a farmer and bullock driver, and his interest in socialism. The original manuscript of *Such Is Life* contained two other well-known books—*Rigby's Romance* and *The Buln-Buln and the Brolga.* Furphy was born in Yarra Glen, Victoria, Australia.

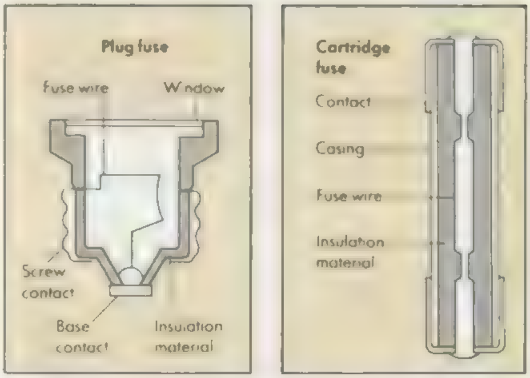
Furtwängler, Wilhelm (1886-1954), was a noted German musical conductor. He conducted orchestras in Berlin, Lübeck, and Mannheim, in Germany; Vienna, Austria; and other European cities from 1911 to 1922. He succeeded Arthur Nikisch as permanent conductor of both the Berlin Philharmonic Orchestra and the Leipzig Gewandhaus Orchestra in 1922. He was born in Berlin.

Furze, a spiny shrub of the pea family, grows wild in Europe and is sometimes called *gorse,* or *whin.* The furze has many dark-green branches which are covered with spines. It grows to a height of 1 metre or more and has fragrant yellow flowers. See also **Legume.**

Scientific classification. The furze is in the pea family, Leguminosae (Fabaceae). It is *Ulex europaeus.*

Fuse is a device that protects an electric circuit against damage from excessive current. A fuse contains a short piece of wire made of an alloy that melts readily. The flow of current through a fuse causes the wire to heat up. The wire melts when excessive current passes through the fuse. This action burns out the fuse and breaks the circuit. It also interrupts the flow of electricity because a fuse is always connected *in series* with the circuit it protects (see **Electric circuit** [Series circuits]). A burned-out fuse—commonly called a "blown" fuse—must be replaced for the circuit to function.

Fuses are manufactured in a variety of *current ratings.* The current rating indicates how much electricity the fuse can carry without burning out. The rating is deter-



Two types of fuses that protect electric circuits in the home are the plug fuse, *above left,* and the cartridge fuse, *above right.*

mined by the diameter of the wire used in the device. Some fuses can carry only a fraction of an ampere, but others carry hundreds of amperes.

In the United Kingdom, electric plugs are usually equipped with a built-in fuse. Fuses are also mounted inside electric outlets. Another type of fuse, called the *cartridge fuse* is used in circuits that require large amounts of electricity, such as those for air conditioners and electric cookers. Miniature cartridge fuses are used in cars and in amplifiers, television sets, and other electronic equipment. Some fuses are specially designed to withstand a current overload for a limited time. These *time-delay fuses* are useful for electric motors that need a large surge of current during start-up.

Many new homes are equipped with automatic *circuit breakers* instead of fuses (see **Circuit breaker**). These devices can be reset and so they do not have to be replaced after a current overload.

Fuse is a device used to cause an explosion. There are two general types, *safety fuse* and *detonating fuse.* The safety fuse allows the person setting off the explosion to reach safety before the blast occurs. A safety fuse is made of black powder enclosed in jute, cotton yarns, and waterproofing materials. When lit, the black powder burns slowly until the flame reaches the explosive. The flame sets off the charge. A blasting cap must be attached to the fuse if dynamite is to be exploded. A detonating fuse has a core of high explosive. It explodes with great violence and is used principally to set off dynamite in quarry blasting. Either a combination of safety fuse and blasting cap, or an electric blasting cap explodes this fuse. See also **Ammunition; Dynamite; Explosive.**

A fuse is a device used to cause an explosion. A range of detonating fuses are shown above.

Fuseli, Henry (1741-1825), was a Swiss painter and art critic. His best-known paintings illustrate works of William Shakespeare and John Milton. Fuseli was born at Zurich, in Switzerland, and named Johann Heinrich Füssli. At 22, he went to England. Later, he went to study the Italian masters in Rome. Fuseli returned to England in 1778 and in 1790 became a member of the Royal Academy. From 1804 until his death, he was keeper of the Royal Academy.

Fusion, in physics, is the joining of the nuclei of two atoms to form the nucleus of a heavier element. It occurs most readily with hydrogen and other light elements. Fusion reactions, also called *thermonuclear reactions,* release a great amount of energy. The sun and other stars derive their energy from fusion reactions, as does the hydrogen bomb.

Fusion occurs when two nuclei that are moving at extremely high speeds collide with each other. High speeds are required to overcome the electric *repulsion* (repelling force) between the two nuclei, both of which are positively charged. Nuclei move at these speeds when heated to temperatures higher than 50,000,000° C. They can also reach these speeds in a *particle accelerator* (see **Particle accelerator**).

The fusion of 1 kilogram of light nuclei produces as much energy as the burning of about 18,200 metric tons of coal. Scientists are still conducting experiments on ways of harnessing the energy of fusion. The fuel used in most fusion experiments consists of a gaseous mixture of *deuterium* and *tritium,* two heavy isotopes of hydrogen.

See also **Nuclear energy** (Nuclear fusion; Present-day research); **Nuclear weapon; Star** (Why stars shine).

Fusion bomb. See **Nuclear weapon.**

Futures. See **Commodity exchange.**

Futurism was an Italian art movement that flourished from 1909 to about 1916. It was the first of many art movements that tried to break with the past in all areas of life. Futurism glorified the power, speed, and excitement of the machine age. From the French cubist painters and multiple-exposure photography, the Futurists learned to break up realistic forms into multiple images and overlapping fragments of colour. By such means, they tried to show the energy and speed of life. In literature, Futurism demanded the abolition of traditional sentence structures and verse forms.

Futurism was created by the poet Filippo Marinetti. In 1909, Marinetti issued the first of many defiant proclamations published by the Futurists. He was soon joined by the painters Giacomo Balla, Carlo Carrà, Luigi Russolo, and Gino Severini; and the painter and sculptor Umberto Boccioni. A Futurist sculpture by Boccioni entitled *Unique Forms of Continuity in Space* is reproduced in the *World Book* article on **Sculpture.**

By 1916, Futurism had lost most of its vigour. Despite its short life, Futurism influenced the theories and works of such modern art movements as Dadaism, Expressionism, and Surrealism.

See also **Boccioni, Umberto; Painting** (Futurism); **Sculpture** (Modern sculpture).

Fuzhou (pop. 1,129,251), also spelled *Foo-chow* or *Fu-chou,* is the capital of Fujian Province in China. The city lies on the Min River, about 50 kilometres from the river's mouth. For location, see **China** (political map).

Fuzhou was once a centre of the tea and camphor trade. In 1842, it became a "treaty port" in which Great Britain gained special trading rights (see **China** [History: Clash with the Western powers]). Fuzhou lost importance as a trading centre in the late 1800's. Japanese troops occupied the city several times during World War II (1939-1945). Fuzhou is famous for its fine lacquerware. The city's products also include industrial chemicals and electronic products.

Fylde (pop. 70,100) is a local government district in western Lancashire, England. It includes the resorts of Lytham and St. Anne's and the market town of Kirkham. Many people from Lytham and St. Anne's work in Manchester or Preston. The area has factories for engineering and producing nuclear fuel elements.

Fynbos is the name given to a large group of South African shrubs. Fynbos have narrow leaves which give them a delicate appearance. The name fynbos comes from the Dutch words *fijn* (delicate) and *bosch* (bush).

Some fynbos can survive fires because although the stem and the leaves are killed, the roots survive. After a fire new shoots grow up from the roots.

Fynbos belong to a group of plants called Euryops. They are grown in gardens because of their large, yellow, daisy-like flowers. Euryops can survive for a long time without water but are killed by frost. They grow best on well-drained soil in a sunny position. Fynbos can grow up to 2 metres tall. One cultivated variety is called the *Paris Daisy.*

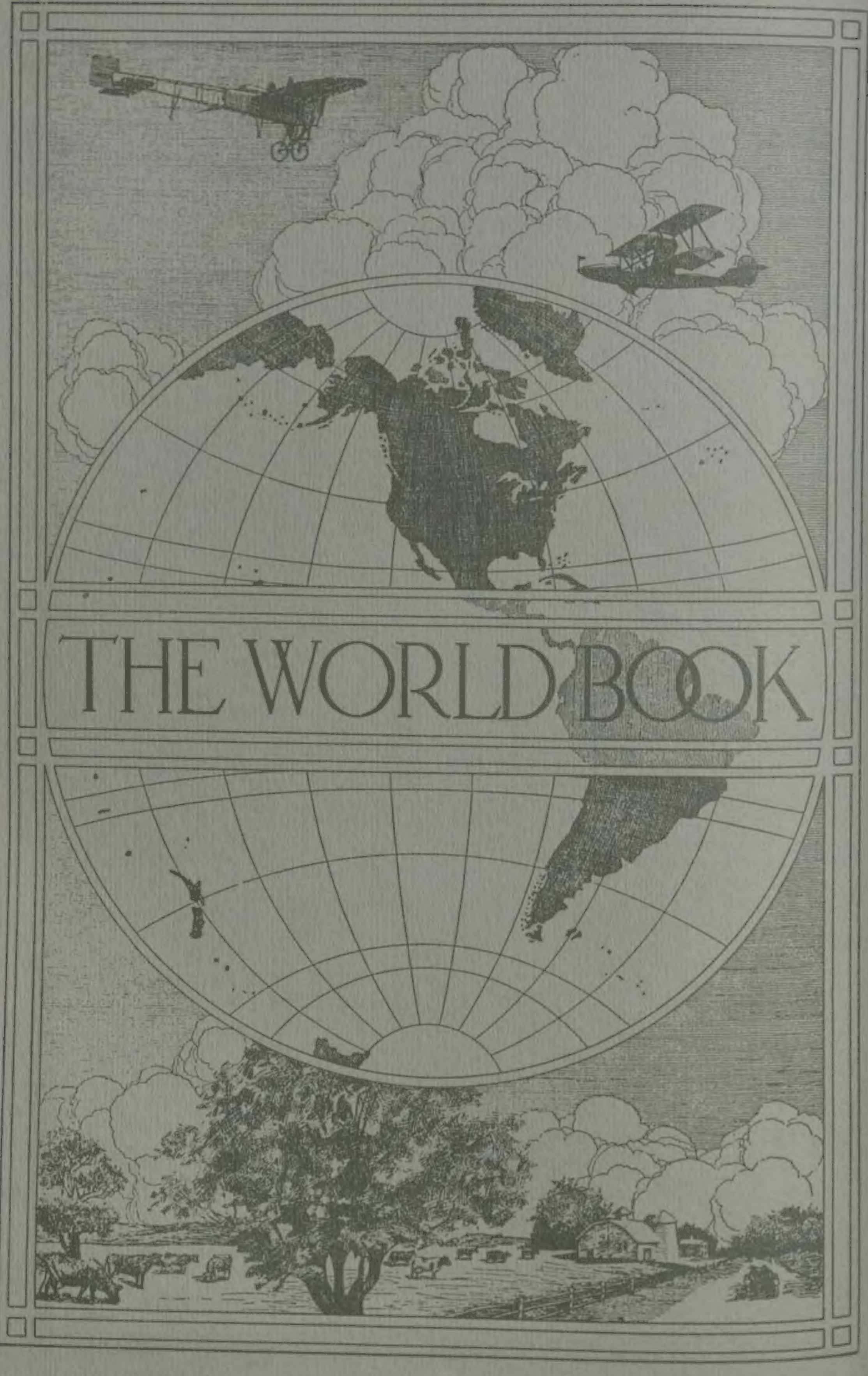
Scientific classification. Fynbos belong to many different groups. The cultivated varieties belong to the daisy family, Compositae (Asteraceae), and the genus *Euryops.* The Paris Daisy is *Euryops tenuissimus.*

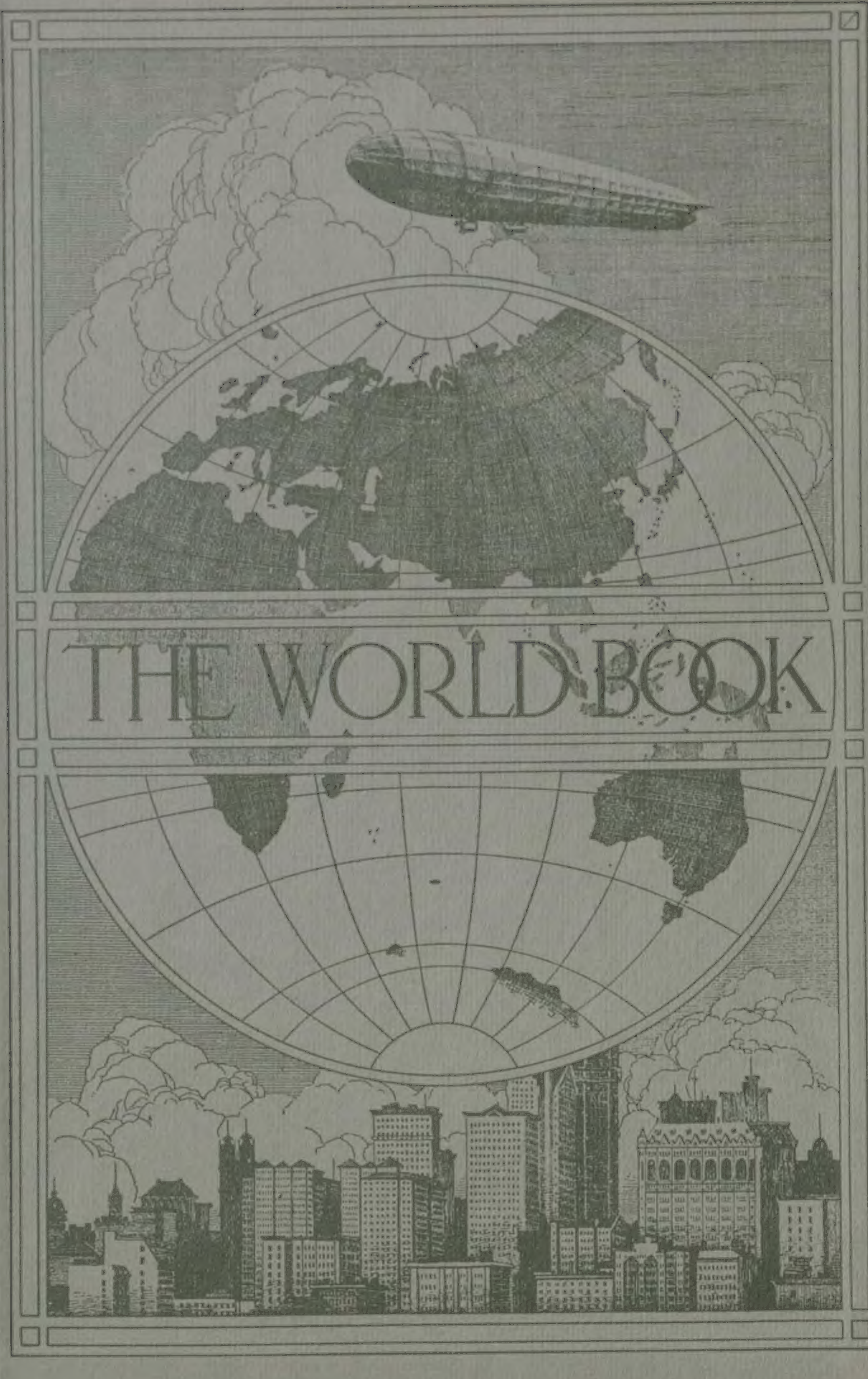
Fysh, Sir Hudson (1895-1974), a leading Australian airman, helped found the Australian airline Qantas in Winton, Queensland, in 1920. Fysh helped build Qantas into Australia's first international airline. In 1922, his plane carried the first official airmail in Queensland. Fysh served as managing director of Qantas from 1923 to 1955 and as chairman from 1947 to 1966. He was president of the International Air Transport Association in 1961 and 1962.

Fysh was born in Launceston, Tasmania, Australia. In 1919, with another pilot, P. G. McGuinness, he laid down the first organized air route across Australia, from Charleville, Queensland, to Darwin, in the Northern Territory.

Red Cross Train (1914), an oil painting by Gino Severini; The Solomon R. Guggenheim Museum, New York City

Futurist paintings express the energy, speed, and excitement that the movement saw in the machine age. Most of these paintings feature multiple images and overlapping fragments of colour.


THE WORLD BOOK


THE WORLD BOOK

THE WORLD BOOK